ELEMENTARY SCIENCE READERS

PAYNE · BARROWS · SCHMERBER

FOURTH BOOK

BENJ. H. SANBORN & CO.

Courtesy U. S. Geological Survey

Colorado Mountain Scene, Showing Erosion

ELEMENTARY SCIENCE READERS

By

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E. GEORGE PAYNE, PH.D.
ASSISTANT DEAN AND PROFESSOR OF EDUCATIONAL SOCIOLOGY
SCHOOL OF EDUCATION, NEW YORK UNIVERSITY

HENRY R. Robbins BARROWS, PH.D.
ASSISTANT PROFESSOR OF BIOLOGY
NEW YORK UNIVERSITY

LOUIS J. SCHMERBER, B.S.
SUPERINTENDENT OF SCHOOLS
PARK RIDGE, NEW JERSEY

FOURTH BOOK

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PREFACE

The Fourth Book in the series of "Elementary Science Readers" is a continuation of the previous books with a different emphasis. The central theme of this book is man in his struggle for adjustment to the earth as his home with emphasis upon organized effort and social adjustment. The part that science has played in this organized effort is kept constantly in the foreground. We might characterize the book as an attempt to indicate the part science has played in man's struggle for adjustment. The authors have not attempted to cover the whole field, but have selected outstanding examples for the purpose of giving the elementary school child the feeling of appreciation and understanding of this effort at adjustment. The technique of teaching this material may be left to the teacher and school administrator who are seeking to enrich the school program with this kind of concrete material.

E. George Payne
Henry R. Barrows
Louis J. Schmerber

SCHOOL OF EDUCATION
NEW YORK UNIVERSITY

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Elementary Science Readers

FOURTH BOOK

SCIENCE AND THE EARTH

As soon as the United States Government decided to construct a canal across Central America to connect the Atlantic and the Pacific Oceans, it became necessary to determine the best route. A canal, such as the one proposed, is an extremely costly thing, involving the expenditures of many millions of dollars. It was, therefore, of the utmost importance that the cheapest, easiest, and most serviceable route be chosen.

In order to decide this question many things had to be taken into consideration, such as the elevation of the land above sea level, whether the soil was soft or rocky, and whether or not lakes could be used as part of the canal to save digging. The men in charge of the undertaking turned to scientists for the necessary information. The scientists, after making a thorough investigation of all possible routes, finally decided that it should be dug through Panama.

The experts who were called upon to decide where this canal should be dug were geologists. But what is a geologist? Why should a geologist know things about the earth that are hidden from other people? He knows about them because he studies the earth to find out of what it is made, and to determine changes which have taken place or are now going on within it, and on its surface. As the biologist studies living things and the astronomer studies the sun, moon, and stars,

so the geologist studies the planet on which we live. His labors have given us information that is used in almost every branch of science and industry.

It is in connection with the minerals that are present in the earth's crust that his work has been of the greatest value to man. As you have probably noticed, some parts of the ground are rocky and others are soft; here are great boulders and there are ledges of rock; in one region are marsh lands and in another mountains and valleys. Thus the substances that make up the earth's crust are different. It is the business of the geologist to determine of what rocks and minerals the crust of the various regions of the earth consists, not only upon the surface but far down under the ground.

By studying the various layers of rock that occur in different parts of the earth, he has gathered a body of facts which tell us much concerning the ancient history of the world. By finding out how long it takes for a given layer of rock to form, he has gained a rough idea as to the length of time required to form the different layers of which the earth consists. By studying the different layers and by examining the remains of animal life found in them, he has determined about how long living things have been upon the globe.

Way down in some of the lowest levels he has found the remains of animals that must have lived hundreds of millions of years ago. These are tiny things that cannot be seen without the use of the microscope. Then, in layers of rock above them, he has discovered deposits left by clams and other water animals. In still higher levels, in order, are found the remains of fishes, frog-like forms, lizards, higher animals, like the dog and horse, and finally, man. Along with these

animals, the various stages of plant life are seen—the simplest plants being found in the lowest levels. The fossil plants become more and more complex as the higher levels are reached.

This knowledge of plants and animals is of the utmost importance to the biologist, because it makes it possible for him to understand living plants and animals, where they come from, and what relation they bear to one another.

In addition to his knowledge of rocks that occur in layers and of the forms of life that are found in them, the geologist has learned much concerning the forces that produced them, as well as the forces that produced other kinds of rocks that do not occur in layers. He has learned that certain rocks, called igneous rocks, are the result of the cooling of materials that once were in the molten condition. He knows what minerals occur in both kinds of rocks. Because of this knowledge he can guide us in our search for particular minerals. If he knows that the rock in a certain locality was formed by the settling of mud and sand at the bottom of bodies of water, he is reasonably sure that deposits of shale (or, under certain conditions, slate) and sandstone will be found there. He knows that petroleum is not associated with igneous rock, so he does not hunt for it in granite formations. In the same way he does not hunt for sandstone or shale in rocks that have resulted from the cooling of hot substances. He limits his search to places where it is possible for these rocks to be formed. When a valuable mineral has been discovered in a certain locality, he examines the region around it and can tell very often in what direction the mineral extends underground, because he knows where the rocks lie that bear it.

He is constantly called upon to tell in what direction beds of coal, iron ore, and other minerals lie. He has learned by long experience that oil occurs in a particular kind of rock. It is this knowledge, combined with his knowledge of structural conditions beneath the surface, that makes it possible for him to tell where to drill for oil.

It is not only in determining the location of minerals that the geologist serves us. In all enterprises which have to do with passing over or through the earth, we are dependent upon him. When we wish to build a railroad, we consult him in order to find what course will make the best road-bed and be freest from rocky obstructions. It is often necessary to tunnel through hills and mountains, because a railroad track must be fairly level. If we know beforehand where there are few rocks, we can save much time and money. When a railroad bridge is to be built, we consult the geologist as to the nature of the ground on both banks, since we must know whether or not there is sufficient natural support for the heavy structure which is to be erected.

In the same way, we must know the nature of the land through which a canal is to be dug; otherwise we might meet with difficulties which we could not overcome. When our country built the Panama Canal, there was much discussion as to whether it should be located in Nicaragua or in Panama. The geologist showed that it would be far more difficult and far more costly to use the Nicaraguan route. Therefore the Panama route was chosen.

The engineers who constructed the great reservoirs of the New York City water supply would have been helpless if the geologist had not given them an accurate description

of the rock formation of the regions where the reservoirs were to be placed and through which the great pipes were to be laid. Had they been without this knowledge, it would have been impossible to be sure that the dams which they were to

Photograph by Publishers Photo Service
Warship Passing Through Culebra Cut, Panama Canal

build would have foundations strong enough to support them. Furthermore, if the geologist had not examined the rock formations in the valleys, the water which was to be dammed back might have run out through crevices between layers of rock and thus be lost.

The great automobile highways which run over all parts of this and other countries are planned in accordance with

the advice given by the geologist. By describing the land which is to be passed over and the rock formations which will be encountered, he helps the road builders to choose the most favorable routes—just as he helps the railroad engineer.

At no time has the work of the geologist been of greater importance than it was during the World War, for it was he who decided where fortifications could best be placed, and trenches dug. He also decided where highways leading to the front should be located, and where streams should be turned from their old beds to flood land in order to prevent the advance of the enemy.

Similarly, the geologist is called upon to tell where ditches can best be dug when it is necessary to furnish desert regions with water; that is, to irrigate them. In regions like the great deserts, that lie in the western part of our country, land which has been so dry for ages that nothing would grow on it is being turned into fertile fields by bringing water to it from a distance. Unless the nature of the land were known, great beds of hard rock might be encountered which would make the digging of these ditches impossible. Besides, the underlying substances might be of such a nature that water brought into the trenches would soak into the ground or be carried away through underground channels and so wasted.

The boundaries between nations have frequently been determined by geological formations. Alsace-Lorraine, lying between France and Germany, contains great coal deposits. For this reason these provinces have been fought for in many wars between France and Germany. Since the extent of coal-yielding land can be mapped out only by the geologist, his importance in this connection can well be understood. Many

countries are separated from each other by natural boundaries like mountains, lakes, and rivers. It is sometimes difficult to tell just where the line between them runs, so the geologist is often called upon to give expert information.

It is frequently necessary for a state to take certain land away from its owners for the purpose of building such things as reservoirs, canals, and roads. Since it is customary for the state to pay the owner a fair price for the land thus taken, the geologist is frequently asked to decide whether or not there are mineral deposits of value in the land. In certain cases, owners of such land have falsely claimed that valuable minerals were present. By consulting the geologist, the state has thus seen that the individual has been fairly treated while the state has been protected from fraud.

These scientists have learned a great deal as to changes that are constantly taking place upon the earth. Many of them affect man because they aid or interfere with things that he is doing. New land is constantly being formed from earth that is being washed down into lakes and into the sea, and shore lines are being washed away and the material from them is being carried to other places. The geologist can tell us how to make passages through the materials that have been deposited in lakes and the sea, and where to build breakwaters to protect the shore line.

He can also tell us where to expect earthquakes and the eruption of volcanoes, since these disturbances of the earth's crust are usually confined to regions where the land is of a definite formation.

Governments, like the United States, realizing the value of the geologists' work have employed them to make maps

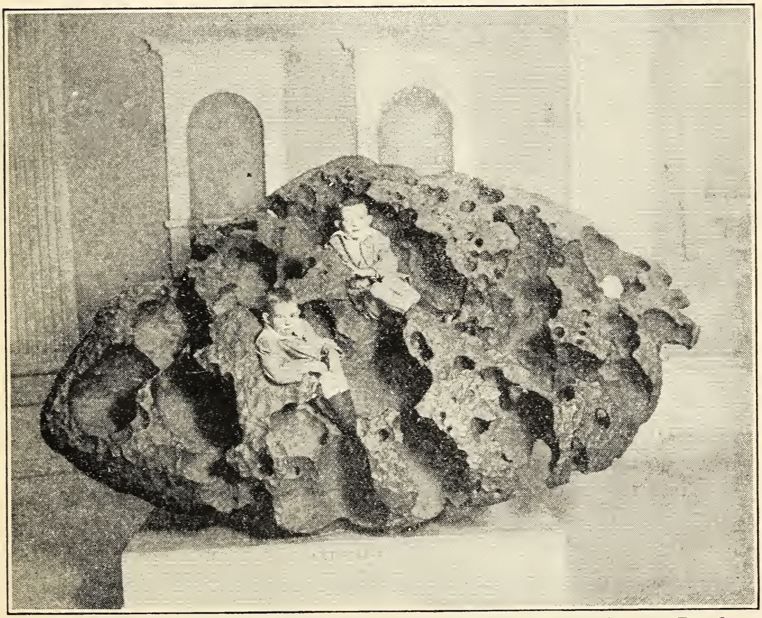
showing the nature of rock formation in every region. When it is necessary to plan some huge undertaking, like the building of a railroad, the digging of a canal, or the enlarging of a harbor, the necessary information is thus available, and can be obtained by writing to the United States Geological Survey, Washington, D. C.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What is a geologist?
2. Of what importance is a knowledge of the layers of rock that comprise the earth's crust?
3. How does the geologist assist the biologist?
4. How does the geologist's knowledge help us in finding minerals?
5. What information does the railroad engineer obtain from the geologist?
6. Of what assistance was the geologist in determining the location of the Panama Canal?
7. How did the geologist assist in the planning and construction of the New York City water plant?
8. What part did the geologist play in the World War?
9. Why is the geologist sometimes called upon when boundaries between nations are in dispute?
10. For what purpose is the geologist employed by the United States Government?

WHAT THE EARTH'S CRUST IS MADE OF

In many museums in this and other countries are specimens of a peculiar kind of rock. They vary in size from small fragments to huge masses weighing several tons. They are unlike the rocks with which you are familiar, for they have a black appearance and they are coated with a thin layer of material resembling enamel. Scattered here and there over their surfaces are many hollow places which give these rocks a very irregular appearance.



Photograph by Brown Brothers

A METEORITE

What is there about these rocks that should make anyone want to put them into a museum for people to look at? These specimens are interesting to us because we know that they fell to the earth from the sky. It is not often, however, that meteorites, as these stones are called, strike the earth, therefore very few people have seen them, except in museums. As a matter of fact, though the earth is constantly being bombarded by meteorites, but few of them actually reach the ground. This is due to the fact that the most of them, upon entering the atmosphere surrounding the earth, are transformed into gas. These "falling stars" burst into flame and soon disappear.

According to one group of scientists, the earth was originally formed by the gathering together of mineral substances similar to the meteorites which have just been described. They think that these masses of matter resulted from the explosion of a sun, and that, after whirling around in space for a long time, they finally united to form the earth mass. They think that then, after long ages, changes took place in the outer surface of the earth that resulted in the formation of a kind of rock called igneous rock.

Other scientists think that the earth at one time was a revolving mass of gases which had been thrown off from the sun. They hold that these gases slowly cooled until the earth was a ball of molten liquid which, after the lapse of ages, gradually hardened on the outside.

Although scientists are not agreed as to how the earth came into being, they are all agreed that its outer surface at one time was composed of a primitive rock, very similar to that which comes from volcanoes, called igneous rock.

Ages after the formation of the earth's crust, water collected in the depressed regions and formed the oceans, while that part of the crust which remained above water became the land. The land was not, as it is now, covered with vegetation. It was a vast expanse of barren rock. We cannot picture in our minds the utter desolation of the young world on which there was no living thing.

The land at that period, as has been said, consisted solely of igneous rock, part of which resembled glass and part of which was like granite, since it was made up of crystals, which are small bodies of matter that look like grains of sugar or rock salt. But the crystals in the different masses of rock were not alike, for they were made up of different substances, and each substance formed its own kind of crystal. The result was that there were many kinds of igneous rock, depending upon the materials of which they were composed.

For many millions of years after its formation, the earth kept getting smaller and smaller, or, in other words, it contracted. The contraction caused its outer surface to wrinkle as the skin of an apple does when it dries out. While these changes were taking place, certain forces were at work on some of the rocks. Gases and liquids were breaking them up into their elements, some of which united again to make rocks of new kinds. Some of the new rocks were composed of crystals and some were not.

When the earth's crust was almost as cool as it is now, rocks appeared that were very different from either the igneous rocks or those that were formed from them. Most of the new rocks were composed of particles from the other two kinds which have been described. They were all alike in

one respect—they were formed under water—but they were not all made of the same materials. Rocks of this kind are called "sedimentary rocks."

But where did the sediment of which they were composed come from? In the early stages of the earth's history, as you have been told, there was neither soil nor sand, plants nor animals. As time wore on, the wind and the rain, gases, heat, and frost made changes in the rocks that caused their exposed surfaces to crumble. Gradually, the surface became covered with fine fragments of these rocks which soon broke up into sand and clay to form soil.

Then the rains carried some of the new-formed sands and clays down the sides of the hills and mountains into the lakes and the oceans. The waves of the seas were also breaking up the rocks along their shores into sand and clay. The sand from both sources collected at the bottom of the seas and became cemented into solid masses, called sandstone.

Year after year the clays, also, collected in layers under the water where they hardened into a kind of rock known as shale. Sometimes masses of pebbles were cemented into a coarser rock called conglomerate. Other combinations of the materials that were washed into the seas produced other kinds of sedimentary rock.

Meanwhile, the first forms of life made their appearance in the waters. They were tiny plants which we believe were similar to some of the bacteria which are on the earth today. Then, later, larger water plants came into being. After a time some of them found their way onto the land and began to grow in the soft soil that was being formed, until most of the land became covered by plants and trees.

Not long after the appearance of the first plants, very small single-celled animals appeared in the waters. At first they were probably not much larger than the bacteria-like plants, but, as time passed on, they changed into all manner of water creatures. Then many of these water animals left the seas and began living on the land just as the plants had done.

You have been told about the beginnings of life on the earth, because plants and animals, even the simplest ones, have a great deal to do with the building of rock. What we have told you about this growth of life is very different from the opinions which men have held concerning this subject down the ages.

Man has always wondered where life originally came from. For many centuries, having very little knowledge concerning nature, he contented himself with guessing. The ancient Greeks were the first people who tried to explain the presence of life. Thales and Anaximander, two of their early philosophers, came to the conclusion that life came from the sea, but they did not attempt to explain just how it came about. The Greeks were right in thinking that life came from the water in the first place, but as to the details of the process they were ignorant. Human life did not appear until long after animals began to live on dry land.

Now let us see what plants and animals had to do with rock making. In some waters there were billions of tiny animals, smaller than grains of sand, that floated near the surface. As they died, their shells, which contained lime, settled on the bottom of the sea. This accumulation of lime, after long periods of time, became limestone.

There were also larger animals whose shells contained

lime. Some of these swam in the water and others crawled along the bottom of the sea. There are no forms of life on the earth today which are exactly like them, although some of them were very similar to our snails and clams. As these animals died, their shells settled under the water, and, in the course of time, having been broken into fragments by the waves and other forces, hardened into limestone. Much of the material which we use for constructing buildings, bridges, and similar works was thus formed from the shells of animals that lived in the seas millions of years ago.

In some cases the shells of these animals were not broken into bits but became cemented together while whole, thus forming rocks that are similar to those which consist of pebbles. This kind of rock is limestone, too, but it is coarser and looser than the kinds first described and cannot be used for building purposes.

There is still another kind of limestone that is the result of animal remains. This is coral. The lower parts of the little animals that produce this substance are cup-like structures composed of lime. They live in great colonies and as they die the lime in their bodies is added to that of those that have gone before. Thus the heap of lime grows higher and higher, and gradually turns into hard limestone. Great islands like the Bermudas were built in this way. In the Pacific Ocean there are many coral islands and coral reefs built by these little animals. Often coast lines for great distances are bordered by coral formations that are slowly increasing in size and making new land.

Very minute plants were also responsible for the formation of certain sedimentary rocks; for instance, the remains of

floating plants gave rise to the great chalk beds in various parts of the earth.

Plants are responsible too for another kind of rock, formed in a different way. Dead plants do not entirely decay when they are covered by water. In the past great numbers of

Photograph by Publishers Photo Service
A GROUP OF CORAL ISLANDS, SOMERSET, BERMUDA

plants and trees were buried underneath the waters of bogs and swamps. Then, due to the pressure of material above them, they gradually hardened into coal. This is the source of all our coal.

There are plants that form limestone, as so many different animals do, by contributing their lime-bearing remains, but the limestone produced in this way is in far smaller quantities than that which comes from animals. The algae which build

up the lime formations around hot springs are examples of these plants.

The most important work done by plants in connection with rock building is in the liberation of chemical substances which bring about changes in rocks already formed. Animals also take part in this work, as shown by referring to coral islands, but they accomplish very little compared with plants.

Due to the work of these chemicals and many other forces, such as great heat and pressure, sedimentary rock does not always remain in the same condition as it is when it is laid down. As was noticed in the case of igneous rocks, great changes are brought about by these forces.

Thus we see that there are three main kinds of rocks. First, there are the igneous rocks which originally surrounded the earth. Second, there are those which were formed at the bottom of bodies of water by the accumulation of minerals and the remains of plants and animals. Third, there are the rocks that have resulted from chemicals and other changes in the igneous and sedimentary rocks.

We have been talking as though most of the changes in the earth's surface were completed in the past, but that is not so. All of them are occurring today. Rocks are constantly being made and being torn down and changed into rocks of other kinds.

This story has been long and perhaps difficult to understand. Rocks are not the simple things that they may seem at first sight to be. And while we have learned many things about them, there is much that we shall probably never know.

QUESTIONS AND TOPICS FOR DISCUSSION

1. How do meteorites differ from other kinds of rocks?
2. What are some of the theories of the formation of the earth?
3. Compare igneous with sedimentary rock.
4. What forces finally produced sandstone?
5. What were some of the ancient views concerning the origin of life?
6. What is the origin of limestone?
7. What part does coral play in the formation of land?
8. How do plants help to break up rocks?
9. What are the three kinds of rock? Differentiate between them.
10. What is the source of coal? Is it being formed today?

THE WORK OF THE OCEAN WAVES

There is tremendous power in the tides of the sea. Men have long recognized this fact and, in various ways, have tried to make use of this power. As yet, however, nothing of importance has been done. For several years engineers have been considering the possibility of building a great power plant on the Bay of Fundy, Nova Scotia, to be operated by the ocean tides.

The plan suggested consists in building a dam across an arm of the bay and then in controlling the inflow and outflow of the water. With a rising tide, the inflow through the channels constructed for that purpose could easily be made to operate powerful water wheels. With a falling tide, the water could be released at will and thus the operation of the wheels continued. The whole matter, it is thought, could be so timed as to provide for continuous operation. With the power thus obtained huge dynamos could be set to work and electricity generated. This, in turn, could be transmitted to all parts of the country.

The bay which the engineers' plan would use for this purpose is only a very small part of the coast line of North America. When we consider the gigantic amount of work which could be done by the power generated at just one point, and then compute the length of the coast lines of the world, we realize that the amount of energy in the ocean tides is beyond our powers of imagination. This mighty force is forever at work upon the land masses of the world. But before we consider what changes the tides make in the outlines

of the land masses, let us examine the work of the ocean waves.

Do you know what a wave really is? When the wind blows upon a body of water it causes the surface of the water to rise and fall. It is the rising and falling which we call waves. If you have ever seen a piece of wood floating upon rough water you probably noticed that it stayed in about the same place. This was because the water was not actually moving along. It was just rising and falling. When wind is blowing across a field of long grass, a similar effect is produced. A wave can be seen to pass across the field, but the grass does not travel with the wave.

Water does move along, though, when it reaches a shallow place like a beach. When a wave reaches its highest point it is higher than the edge of the land, so, as it flattens out, the water flows some distance onto the land. This also happens when a strong wind catches the top of a wave and blows the water forward, forming white caps. You have probably seen them when the water was very rough.

The constant movement of waves against the land is effective in changing shore lines, because they break down the materials which form the land and carry it to other locations. When there are hard rocks along the shore, the waves make extremely slow progress. Sometimes they wash away the land around these rocks, leaving them as islands. At other times, ridges of hard material are left projecting from the land after the soft earth on both sides of them has been washed away. In this way promontories are formed. When the waves attack a mass of land the lower layers of which are softer than the upper ones, caves are often produced, because the softer materials are washed out from under the harder.

When these caves are worn deep enough to undermine the hard rocks above, these rocks fall.

Since the ocean is constantly working against the shore lines, it is gradually straightening them out, since its waves are wearing down regions that project out from the land and

Courtesy U. S. Geological Survey

Island of Rock Formed by Ocean Waves

are filling in bays with materials which they have carried from the projecting regions.

The rocks which are washed down from the land are continually being ground into finer pieces, because each incoming and outgoing wave causes them to rub against each other. The result of this constant grinding is the formation of the sand which makes the beaches.

There is another kind of wave, called a "tidal" wave, which is different from the ones just described. These waves are not very well named because they have nothing to do with the tides. A tidal wave is one that is caused by a hurricane, which is a severe windstorm in which the wind travels around in a circle of several hundred miles. This whirling of the wind disturbs the water in such a way that great waves, sometimes a hundred feet in height, result.

It is easy to see that such waves, rising along a coast, will sweep almost everything before them. Tidal waves do their greatest damage in bays and in the mouths of rivers. Ships have been carried considerable distances inland, and large towns have been completely wiped out by them. Galveston, Texas, was destroyed by one of these waves in 1900.

Very similar in their effects are the waves which follow earthquakes occurring under the ocean. Some of them have been even more destructive than those produced by hurricanes, because of the enormous quantities of water which they have hurled against the shore. They often make great changes in coast lines, because they carry so much soil and rock inland.

Sometimes when volcanoes erupt, the explosions produce great waves. Such was the case when the island volcano Krakatoa, in the Pacific Ocean, exploded. The resulting wave killed many thousands of people who lived on nearby islands.

So far, you have learned the effects of different kinds of waves on the land. Let us now examine the motion of the water in which the entire ocean takes part. This motion is known as a tide. Twice a day the surface of the ocean rises

and falls. If you have ever been at the seashore you have noticed that the water comes up higher on the beach at certain times than at others. When it reaches its highest point it is said to be at high tide, and when it is at its lowest level it is said to be at low tide.

Courtesy U. S. Geological Survey

Coast near Monterey, California

Though the movement of the water due to the tides is slow compared with that of the waves, the tides are very important agents in effecting changes in coast lines. One of the most important things that they do is to raise the surface of the ocean so that the waves do their work higher up on shore. Floating things are brought to places which they could not reach if it were not for the elevation of the water by

the tides. As the tides fall, materials that otherwise would be high and dry are washed down into the sea.

The high tides also moisten rock and soil that otherwise would be out of reach of the water. By doing this they make possible the breaking up of the rocks into their elements, because many chemical changes take place only when water is present. Besides, the pressure of the water in the crevices in the rocks aids in tearing them apart. Then, too, in cold weather, water which is carried to these places above the shore lines fills crevices and freezes. When water freezes it occupies a larger space. Rocks are split apart because they cannot withstand the expansion of the freezing water.

In addition to breaking up the rocks on the shore, the tides do another kind of work. They bring water and food to animals and plants that live above the shore level. Animals and plants, as you know, have a great deal to do with the formation of certain kinds of rocks, and, as you will see later, they are sometimes very important preservers of shore lines.

You now know some of the effects of the tides and waves on the lands masses. There are other movements of the ocean, called ocean currents, which involve great areas of water. These are wide streams of water in the ocean itself. They are a great deal like broad rivers flowing around and around, but, unlike most rivers, they frequently change their courses. The ocean currents result from the almost constant blowing of the wind in one direction.

There is one current, the Gulf Stream, which flows near the eastern coast of our country, bringing warm water from the southern seas. It has a great deal to do with keeping parts

of our country from getting too cold. Another current, called the Labrador Current, flows southward from Labrador along the eastern coast of Canada and Maine. This current brings cold water and consequently lowers the temperature of the regions mentioned. The Japan Current flows northward along the coast of Japan. If it were not for this stream Japan's temperature would be considerably lower than it is. There are other currents within the ocean, and they all have their effect upon the lands near which they flow.

Since ocean currents change the temperature of the countries which they touch, they determine what kinds of plants and animals shall live along the water's edge. Many shore lines are protected by long narrow islands, called coral reefs, which lie a short distance from the shore. These reefs, as you have already learned, are built by very small animals whose skeletons of lime make solid land. They form a barricade against the ocean waves. If it were not for these coral reefs, the nearby shores would be washed away by the waves pounding against them.

There are many other animals, like clams and oysters, which require water that is neither too warm nor too cold. Their shells, as we have seen, take part in the formation of rock. Thus the ocean currents, by making it possible for certain animals to live in particular places affect the nature of the shore line.

The ocean currents, by changing the temperature of the water, also determine what kinds of plants shall live on a particular shore. Plants often protect the shore by growing over the soil and holding it in place by their roots, so that the water cannot carry it away. In some places, especially

in warm regions, plants and trees extend out from the land into the shallow waters. Then new plants grow upon them. Sand and clay pack against them and before long new land has been formed. In this way the coast lines sometimes move outward to the sea. In other regions, plants growing along the water's edge send their roots into small cracks in the rocks and split them apart, because the force exerted by a growing plant is very great. Their roots also make little tunnels in the rocks by which water can enter, and water, as we have seen, assists in the breaking up of rocks.

In addition to keeping the water at a temperature which makes it possible for plants and animals to live, the ocean currents carry materials eaten by water animals from one part of the ocean to another. Thus many animals that are important in building new land are supplied with food.

There is still another kind of ocean current. The water in the neighborhood of the North and South Poles becomes very cold. When any part of a body of water becomes colder than the rest it flows to the bottom. For this reason, the cold water of the Polar regions flows under the warmer water of the other parts of the ocean. Undersea currents are thus formed which flow great distances from the Poles. These currents carry oxygen to animals in the deep parts of the ocean, thus making it possible for small animals, whose shells will form limestones, to live. They thus help in the changes that are taking place in the shore lines.

The work done on a particular coast depends, to some extent, upon whether the land is rising or sinking or whether it is stationary. When the edge of the land mass is rising, more and more of its beach is being raised above water. This

causes the shore line to move farther out, and it makes more shallow water, because the bottom of the ocean near the shore is rising too. Waves now break a considerable distance from shore, because they strike the shallow water farther out. Instead of carrying sand and rock nearly up to the land, they leave it where the water begins to be shallow. A ridge of new land, called a sand bar, is now formed by the sand and rocks which are piled up.

Sand bars may extend along an entire coast, just as they do along our eastern coast from New Jersey to Florida. They may lie a good many miles from the water's edge depending upon the rapidity with which the land under the water is rising. Most sand bars keep getting wider and wider as sand and rock are laid upon them by the waves.

The water between a sand bar and the shore is called a lagoon. Lagoons gradually become filled up with sand that is blown in from the sand bars and by material that is deposited by rivers that flow into them. In the course of time the lagoon disappears, for the entire space between the bar and the old shore line becomes filled.

Now that you have seen what happens to the shore line when a coast is rising, what do you suppose takes place when it is sinking? As the land sinks, the edge of the water keeps touching ground that is farther inland. What used to be shallow water off-shore becomes deeper and deeper. The sea now begins to fill up hollow places, like valleys and plains, that are near the shore. We have a constantly changing shore line which is creeping farther and farther inland. The waves have new land to beat against. They first tear loose the sand and soil; then they begin work upon the hard

rock. Sand and gravel are carried out to sea and a new beach is built up if the land does not sink too rapidly. Hills and mountains consisting of rock resist the action of the waves and form promontories and islands.

When land is sinking, the shore line becomes very irregular, because the sea creeps up all valleys and over all lowlands, leaving the mountains and highlands as projections above the sea. The coasts of Maine and Alaska are examples of what happens when land along a continent's edge is sinking. Your map will show you the great number of bays, islands, and promontories that are present.

Thus we see that one result of the action of the waves is to carry sand, soil, and rock from the dry land down to the sea. Another is to straighten out the shore lines, because portions of land that project into the water are worn away and bays are filled up with materials which have been carried to them by the waves.

QUESTIONS AND TOPICS FOR DISCUSSION

1. Describe the action of a wave.
2. In what way do the ocean waves change the shore line?
3. What is a tidal wave? Where do they do the most damage?
4. How do the tides affect the coast line?
5. What are ocean currents? What effect do they have upon the land?
6. Where does the Labrador Current flow? The Japan Current?
7. What are undersea currents?
8. How do undersea currents affect plant and animal life?
9. When a land mass is sinking, what is the nature of the coast line?
10. What is a lagoon? Why do they eventually disappear?

INLAND WATERS AND WHAT THEY DO

For many generations, a tribe of Indians that lived near the mouth of the Mississippi believed that the source of that river was in the clouds far to the north. They had every reason for so believing. Had not a great medicine man told them so? Was there anyone bold enough to question the word of a medicine man? Furthermore, many members of the tribe had made long journeys up the stream, and none of them had seen anything to cause them to think that the river had any other origin. Even the tribes that lived above them said that the source of the river was in the distant north.

Like most stories that are handed down from generation to generation, this one had taken on a different form than that which it had in the beginning. The medicine man had told his listeners that the water of the river came from the clouds, not that the river actually flowed down from them. What he meant was that the water that formed the river descended from the sky in the form of rain. Though the explanation of the medicine man was correct as far as it went, he did not go back far enough, since he did not tell where the moisture that forms the clouds comes from.

The source of all the water on the continents and islands is the sea. In the form of vapor it rises into the air where it forms clouds that are borne over the land by the wind. Then, as you know, it descends to the earth as rain which is the source of the water in lakes and streams. But we have all seen clouds form over land that is far from the sea. Where does their water come from? These clouds are the

result of evaporation from rain-wet ground, from plants and trees, and from lakes and streams. But this water, too, originally came from the sea.

The water that falls on the land does the same kind of work that the ocean waves do—it wears away soil and rock and carries them to other places. As the ocean is constantly straightening out irregularities in the shore lines, so are the inland waters smoothing down the higher portions of the earth's surface. If you have ever noticed how quickly rain can wash a pile of sand away, you can understand how it acts on the surface of the land. Of course most of the ground is harder than a sand pile, and so the rain works much more slowly; but the final result is the same—the high places are washed down and carried away.

Almost every part of the earth receives its share of rain. There are some that do not, because the rain-bearing clouds do not reach them. This happens when clouds from a warm part of the sea are blown over mountain ranges near the coast. The cool air surrounding the mountain causes the water in the clouds to fall to the earth, which leaves no rain for the regions beyond. This is the reason that much of Utah and Arizona are deserts.

When clouds are borne by cool winds over warm lands, there is no such drop in temperature and consequently no rainfall. The Great Sahara Desert in northern Africa suffers from the lack of rain for this reason.

Let us see what happens to the rain after it reaches the ground. Some of it almost immediately changes to water vapor and rises into the air again to form clouds. Some of it flows down rock and hard earth and unites with streams

and begins its journey back to the ocean. A large part of the rain water soaks into the ground. Much of it is absorbed by the roots of plants and is finally returned by them to the air through their leaves. Some of it finds underground channels which carry it to the surface farther down the sloping ground where it bubbles out as springs which flow into streams and rivers.

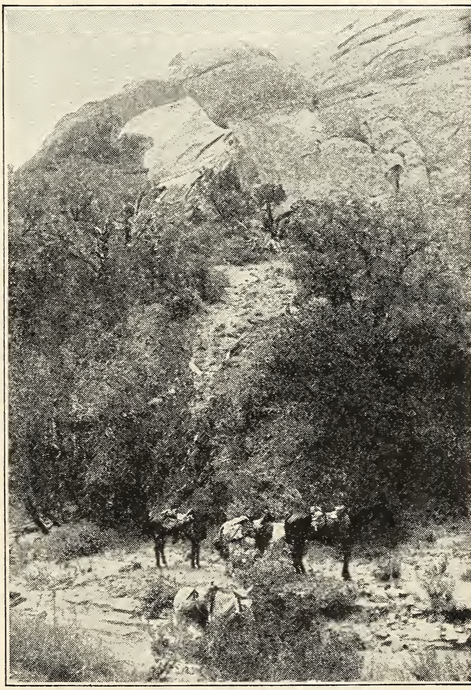
When water that has soaked into the ground collects far enough below the surface so that it is not heated by the sun, it gives rise to cool springs. Much of our drinking water comes from reservoirs that are fed by such springs. Some of the rain that trickles through the ground reaches places where the temperature of the earth is very high. Hot water

Courtesy U. S. Geological Survey

The Punch Bowl, Yellowstone National Park

often gently bubbles up from these regions forming hot springs. Again it may spurt high into the air producing natural fountains similar to the geysers in Yellowstone Park.

The water from many geysers and hot springs contains substances, like silica and lime, that have been dissolved out of the rocks. When this water falls to the ground, it cools and drops its load of minerals, thus forming cones around the mouths of the geysers and hot springs. Minerals are also brought to the surface by cold springs, but cold springs do not bring as large quantities to the surface as do the hotter waters, because hot water is able to dissolve more of them.



Courtesy U. S. Geological Survey
Owl Natural Bridge, Arizona

Frequently, underground streams dissolve and carry away large quantities of material and in this way produce great caverns. Mammoth Cave, Kentucky, is an example of such a cavern. It has many chambers and passages extending over an area eight or ten miles wide. Added to

gether these total a length of nearly two hundred miles. The roofs of such caverns occasionally fall in, resulting in great holes in the earth. At other times a part of the roof falls, leaving a portion which takes the form of a bridge across the "sink hole." Some of the "natural bridges" in different parts of the world had such an origin.

The water that flows down the sides of sloping land does more to change the surface of the earth than anything else. Streams that begin as small brooks gradually grow larger and larger, because rivulets flow into them all along their course. In their passage downhill, streams constantly wear their channels deeper and deeper. This work is done not only by the running water, but by the sand and stones which it carries.

The great rivers of our country, like the Mississippi and the Hudson, whose beginnings are in small streams, become very wide at their mouths. Most rivers, compared to their valleys, are very narrow, and one would be apt to think that the rivers were there because the bottoms of their valleys are lower than the surrounding country. The truth is, the valleys are there because the rivers made them.

From the time that a river has first formed its channel, its banks begin to wear away, for the rain which flows down the sloping sides carries soil and rock with it. This process is aided by the sun, the wind, and the frost, which are ever at work upon exposed land. As time goes on, the river banks slope more and more and their valleys become wider and wider.

When a river reaches gently sloping land, it does not flow as swiftly as it did before. At this point sand and soil

which it has been carrying are dropped. These, after a time, accumulate in such large quantities that they interfere with the passage of the water. When this happens the river digs out a new channel through the deposited substances.

When a river flows over land that is nearly flat, it usually follows a crooked course, since it turns here and there hunting for the easiest passage. Such rivers change their channels frequently, because when the water is high, particularly in the spring, they overflow their banks and seek new pathways. Very often such rivers do not return to their old channels but continue in the new ones. In the course of time, crooked rivers gradually become straightened as their curves are worn away.

A river in its course sometimes runs into hollow spaces or finds its passage stopped by higher land. When either condition occurs, water accumulates and a lake is formed. The water keeps rising until at last it finds a point where it can flow down hill again and continue as a river. As soon as a lake is formed, the sand and other materials which are carried into it begin to settle to the bottom. This settling continues until at last the lake becomes filled. The water then digs a channel through this material and continues down the slope.

Wherever a lake is found in a river system, we can be sure that the river is not very old, because old rivers have filled up their lakes with the materials which they have deposited. The Saint Lawrence is an example of a river which has not had time to fill up its lakes. Some day, even the Great Lakes may be filled, and the Saint Lawrence River become a comparatively narrow stream running through them.

Just as rivers empty material into lakes, so do they deposit it in the ocean. Sometimes the ocean currents are strong enough to carry these substances away from the point at which they have been deposited. But when there are no strong ocean currents present, the materials collect in the

Courtesy U. S. Geological Survey

DELTA OF CHELAN RIVER ENTERING THE COLUMBIA

ocean bottom for considerable distances from the mouths of the rivers. After a time new land is built up which interferes with the passage of the river water. The river then plows through the materials which it has deposited, sometimes forming several channels. Such collections of materials through which the river channels pass are called deltas, be-

cause most of them are shaped like a triangle, which is the form of "delta," one of the letters of the Greek alphabet. A delta two hundred miles long is at the mouth of the Mississippi River, while the delta of the Nile is 146 miles long.

When a stream suddenly plunges over a precipice, a waterfall is formed. If the earth under the lower part of the fall is softer than that above, it is washed away first. The water, as it continues to fall, then undermines the portion above, and this, having nothing to support it, caves in. The result is a constant retreating of the fall. This process may continue for a long distance, as was the case with Niagara Falls, which at one time were at the lower end of Niagara Gorge.

In the course of time, even the steepest falls disappear as the channels of the stream are worn down. For this reason there are no falls in old rivers. The Mississippi River probably once had great falls in its course which have long since been worn down.

When the land near the source of a river is rising, the water flows more rapidly and carries more sand and rock than it did before. But when only that portion of the earth near its mouth rises, the river is either slowed up or forced to find a new way to the sea. For this reason we sometimes find lakes near the seashore in old river courses. At other times several rivers, the courses of which have been changed by the rising of the land, unite and empty into the ocean as a single stream.

The sinking of land near the source of a river may cause the water to flow more slowly or to change its bed. When the land near the river's mouth sinks, the old river bed lies

in the ocean and the stream which before emptied into the river may now empty into the sea.

Rivers which flow through countries in which there is little rain sometimes run dry during part of the year. When heavy rain falls they rush down their channels with great force, carrying much rock and soil with them. The same thing happens where the trees have been cut from the hills along the river banks, since there is nothing to hold the water back. Such rivers do great damage in the spring, because the melting snow releases great quantities of water.

We have mentioned lakes that occur in the courses of rivers, but there are other lakes which are not drained by rivers. They are salt lakes like the Great Salt Lake in Utah and the Dead Sea in Asia. Since these lakes have no streams carrying water away from them, the only way that it can escape is by evaporation. Such lakes remain at about the same level, because the quantity of water flowing into them just about equals that which evaporates into the air.

The water of these lakes is salty since the streams which empty into them carry salty material which they have dissolved out of the rocks over which they passed. When water evaporates it leaves behind everything that is dissolved in it; so year by year these lakes are getting saltier and saltier. If this process continues long enough they will become filled up with salt. There were salt lakes in the distant past which left great deposits of salt. It is from these salt beds that we get most of our salt today.

You have been told in another chapter how the streams are carrying materials from the highlands into the lakes and seas where they produce rock. This is one of the most im-

portant kinds of work that running water does, for it helps fill up the hollow places in the earth's surface.

Thus we see that the streams are digging channels in the surface of the land and that the rain, with the help of the other forces of nature, is widening these channels into great valleys, and that the materials carried down by the water are being deposited in the sea.

If this process were to continue uninterruptedly for a long enough period, the time would come when all of the land masses would be flattened out and then would finally be washed into the ocean. But other changes are taking place all the time—the surface of the earth is rising in some places and sinking in others. The result is that there is always elevated land for the water to work upon.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What is the source of all fresh water?
2. Why are there desert regions in some of our western states?
3. What becomes of rain after it reaches the ground?
4. What is the cause of hot springs?
5. Explain the formation of Mammoth Cave.
6. Describe the course of a river flowing over a flat country.
7. How can you tell a young river from an old one?
8. Why do falls sometimes retreat long distances?
9. What effect does the rising of land near a river's mouth have upon the course of the river?
10. Account for the presence of salt lakes.

WHEN THE EARTH TREMBLES

One day in 1923 the people of Tokio, Japan, were carrying on their usual occupations; they were happy in their homes and in the companionship of their loved ones. The next day their occupations were gone, their homes were in ruins, and the lives of thousands had been blotted out. The great earthquake of 1923 had come and gone.

Nothing remained of what had been homes and other buildings but piles of rubbish. The streets were choked with broken timber, household goods, and a thousand other things. Underneath the fallen buildings were the dead and the wounded. But, worst of all, fire had broken out in many places, for the embers from demolished stoves and furnaces had been scattered throughout the wreckage. Though the survivors toiled with all their might, they could not subdue the flames. The destruction was soon complete. As the result of this earthquake, the most disastrous in loss of life in the history of the world, 200,000 human beings died and 250,000 others were injured or missing.

Let us see what this thing which we call an earthquake really is. Earthquakes are tremblings, or quiverings, of the earth's crust. Most of them are the result of the slipping of one portion of the crust upon another. You can get an idea of what happens when one portion of the earth's crust slips beyond another by laying two books side by side on a table and then sliding one a short distance ahead of the other. The books before being moved represent the earth before an earthquake. After being moved they represent it after

the shock. Sometimes one part of the crust slips above the other. If you will raise one book a fraction of an inch, still keeping them side by side, you will see what takes place when the slipping is up or down.

Although these slippings of the earth's surface are not more than a few inches or a few feet in extent, they produce great disturbances in the surrounding territory. Sometimes the vibrations thus produced extend around the globe. These slippings of the ground take place where the crust is weak. Such weak spots are often due to changes which result from the contraction of the earth. At other times some force, like the pressure from gases underground acting upon these weak spots, is all that is necessary to bring about the shifting of the crust which results in the earthquake.

Other earthquakes occur when caverns caused by the dissolving of minerals cave in. Mammoth Cave in Kentucky is the result of the dissolving of minerals by underground water which carried them away and left a great cavern. If the roof of any part of this cave should fall, the earth nearby would tremble, producing an earthquake.

Slighter shocks are often noticed before the main disturbance. This means that the earth has begun to give way. Other smaller shocks follow the main one, because it takes considerable time for the displaced rocks to fall into place. Thus you see earthquakes are quiverings, or tremblings, of the earth's crust which are produced by sudden changes in the arrangement of portions of the earth's surface.

Great damage results from some of these disturbances, because the severe shaking of the ground causes the destruction of buildings, bridges, railroads, and other structures.

It often happens that great numbers of human beings lose their lives when these structures fall. Fire usually breaks out in the wreckage and adds to the property damage and the loss of life. All of these terrible things happened in the Tokio earthquake of 1923.

Sometimes the tremblings of the earth are so slight that one would never know that they had occurred unless it were for delicate instruments, called seismographs, which are made for the purpose of detecting them. These instruments are so sensitive that they are affected by even the slightest vibrations, no matter in what part of the earth they take place. Frequently, the seismograph tells us that an earthquake has occurred although none has been reported from any part of the world.

Earthquakes originate in the crust under the sea, as well as upon land. The seismograph indicates that many such earthquakes occur. Sometimes great waves, often called tidal waves, which result from such a disturbance sweep in from the sea and do great damage to the coasts. Large boats have been swept by them considerable distances inland, where they remained after the water subsided.

One of the worst earthquakes on record occurred at Lisbon, Portugal, in 1755. Without any warning a terrible rumbling was heard and the earth began to rise in waves as does the sea in a storm. The effects of this earthquake were felt as far as the coast of Africa and the Alps Mountains. Following the earthquake, a great wave which is said to have been fifty feet high swept in from the sea. It completed the destruction resulting from the shaking of the earth, and drowned thousands of the inhabitants of the city. It is

estimated that 40,000 people lost their lives in this great disaster.

In our own country, in 1811, occurred the Mississippi Valley earthquake. It was different from the Lisbon earthquake in that it consisted of about two thousand different shocks that extended over a period of three months. The

Courtesy U. S. Geological Survey

CRACKS IN GROUND CAUSED BY EARTHQUAKE

same wave-like motion of the earth was reported as occurred at Lisbon. Some of the cracks in the ground were thirty feet wide and have never closed. Another great earthquake occurred at Charleston, S. C., in 1886. Almost every building in the city was injured in one way or another, and considerable damage was done to the surrounding country. This earthquake was felt as far north as New England.

One of the most severe shocks that the Western Hemisphere has known took place in California in 1906. Occasional tremblings of the ground had been felt in that state ever since its first settlement. Up to the time of the great disaster, however, none had been of a serious nature. It is therefore not surprising that the people of California paid little attention to the series of slight shocks which preceded the great one of April 18. Many people were caught in buildings who would have been saved had they heeded the warnings.

The main shock lasted only about a minute, but in that period of time it destroyed part of the city of San Francisco and many towns. The area of destruction was about 350 miles long and 70 miles wide. In the city of San Francisco the shaking of the earth caused many buildings to fall, or so damaged them that they had to be torn down. Another serious result of the disturbance was the destruction of sewers, water mains, electric wires, and similar necessities.

As always happens when a disaster of this kind hits a city, fire broke out in many places. Since the work of the fire department was interfered with by the falling of buildings into the streets, by the destruction of fire fighting apparatus, and by the lack of water resulting from the breaking of the water pipes little could be done to check the flames. Far greater than the damage done by the earthquake itself was the ruin produced by the fire which swept over a wide area of the city. As a result of this disaster, 700 people lost their lives, about 150,000 were made homeless, and 25,000 buildings, valued at $100,000,000 were destroyed.

There have been other violent earthquakes on this continent, like the one that took place in Mexico, New Mexico,

and Arizona in 1887, and the one that shook Southern Alaska in 1899. But the California earthquake, occurring as it did in a thickly populated region, resulted in far greater damage than any other on this continent of which we have record. A year after the San Francisco disaster, another occurred at

Courtesy U. S. Geological Survey

San Francisco After the 1906 Earthquake

Kingston, Jamaica. Great damage was done to property and to human life. This shock was peculiar in that the region affected was only about ten miles in diameter.

Another recent earthquake was the one that destroyed Kangra, India, in 1905, killing over 18,000 people and demolishing over 100,000 buildings. Still another was the one that destroyed 100,000 lives in Italy in 1908.

Earthquakes are more likely to occur in some regions than in others. In England these rearrangements of the earth's crust never occur. Some scientists believe that the earth's crust is thinner in some parts than in others, and that it is this thinness which accounts for the occurrence of earthquakes. They believe that the crust is unusually thick in the region of England and very thin in the region of Japan. Other scientists believe that earthquakes take place where there are weak spots in the crust due to contractions of the materials of which it is composed, chemical action, unequal pressure of overlying substances, or other causes. At any rate, we know that earthquakes are limited to fairly definite regions. The western coast of North and South America, the region bordering the Mediterranean Sea, Southern Asia, the East India islands, and Japan are the regions where they most frequently occur. However, there are other localities, like our Southeastern States and Southern Australia, where they occasionally take place.

If you live in a region, like New England, where there have never been serious shocks, you will probably never know what an earthquake is, unless you move to a locality where they occur. If, on the other hand, you live in San Francisco, you will probably experience them as long as you remain there.

There is one encouraging thing about earthquakes. After there has been a severe shock in a particular spot, there is little likelihood of the occurrence of another of similar magnitude, because the severe shock removed the greater part of the strain that the earth's crust was under. This is not true, though, in regions where there are active volcanoes, because

earthquakes in such places are for the most part the result of the explosion of gases, which may take place over and over again. Southern Italy is a country where severe shocks due to this cause are of frequent occurrence.

Earthquakes, because of the sudden nature of their appearance, are apt to lead us to believe that they are more effective in modifying the land areas of the earth than they really are. Although disturbances, like those at San Francisco and Lisbon, destroy much property and cause the deaths of many people, their effect upon the surface of the earth is almost nothing.

QUESTIONS AND TOPICS FOR DISCUSSION

1. Describe the effects of the earthquake that shook Japan in 1923.
2. Why do slight movements of the earth's crust often result in great destruction of life and property?
3. What are seismographs?
4. In what countries do earthquakes never occur? Why?
5. Describe the earthquake that occurred at Lisbon in 1755.
6. How did the Lisbon earthquake differ from the one that occurred in the Mississippi Valley in 1811?
7. What was the extent of the damage done by the San Francisco earthquake in 1906?
8. To what regions of the earth are earthquakes as a rule limited?
9. After a severe shock is there likelihood of the occurrence of another severe one?
10. What is the cause of earthquakes?

WHEN VOLCANOES COME TO LIFE

In August, 1883, the people living in the East Indies heard a succession of the loudest sounds recorded by man since the beginning of human history. They were caused by the explosion of Mount Krakatoa, a volcanic island, located in the Strait of Sunda, between Java and Sumatra. The explosions blew off the top of the volcano and hurled high into the air a mass of rock and other materials estimated as high as a cubic mile in bulk. It is said that the great clouds of dust and ashes rose to a height of seventeen miles. Traces of this dust remained in the air for a period of three years.

As a result of the explosion, waves fifty feet in height broke upon the shores of the neighboring islands. Whole towns and villages were completely destroyed and between thirty and forty thousand people on these islands lost their lives.

Volcanoes do not all perform in the same way that Krakatoa did; yet all of them are the result of the same cause—the presence of pressure underground which forces materials to come to the surface. These materials are for the most part molten rock and gases.

Many explanations of their presence have been offered. Some geologists maintain that the center of the earth has been hot since its formation. Others say that ages ago the crust alone was hot and that there are still pockets of molten rock and gases within it. One group thinks that the pressure of overlying masses is sufficient to produce enough heat to melt rock, while the members of another group are sure that chem-

ical activity is responsible. Recent discoveries have led many scientists to think that the earth's internal heat comes from radium and other metals.

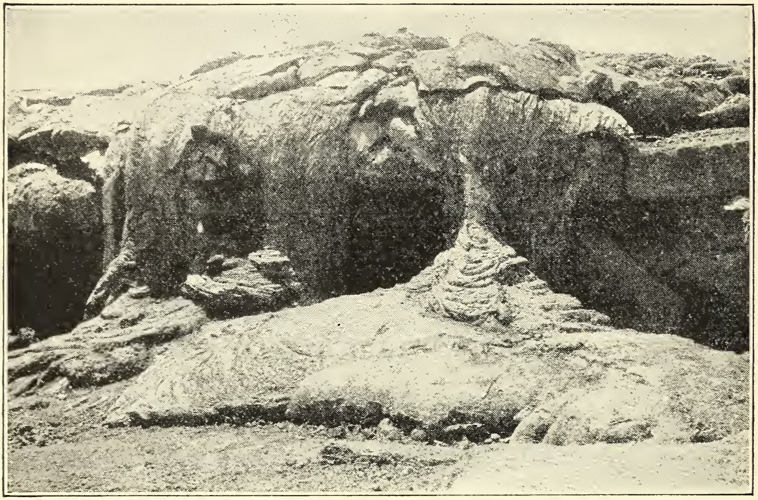
But whatever be the cause, we know that there are in certain regions hot gases and molten rock underground. We are interested, in this chapter, in what happens at the points where these substances come to the surface. The places where molten rock comes to the surface are called volcanoes, and the molten rock is known as lava. Around the opening in the earth, which is called the mouth, or crater, of the volcano, lava and other materials from the volcano accumulate, and, in many cases, in the course of time build great mountains.

Explosions, like the one which occurred at Krakatoa, often blow the molten rock into fine particles which are thrown into the air. This is the source of volcanic dust. Clouds of smoke and steam are often poured into the air to immense heights, and frequently rocks and cinders are hurled upward to fall upon the surrounding country. Rain, which results from the gradual cooling and condensation of clouds of steam, frequently mixes with volcanic dust in the air and produces volcanic mud. This pours down the mountain side and buries everything in its path. Heavy thunder and lightning often accompany an eruption.

In some cases, after a violent eruption which results in the expulsion of ashes and cinders, lava flows down the sides of the volcano. This flow may continue for long periods of time, being interrupted at intervals by minor explosions. In other cases no outpouring of lava follows the explosion.

There are volcanoes, however, in which no explosions of moment occur. In such cases no ashes, dust, cinders, or other

materials are hurled into the air. Instead, molten rock flows from the mouth, or crater, or through cracks in the sides of the mountain. It is thus seen that the important fact in connection with volcanoes is not the way they erupt, but that they relieve the pressure within the earth.



Courtesy U. S. Geological Survey

Lava Cascades, Kilauea, Hawaii

It has frequently happened that a volcano, absolutely quiet for hundreds of years, has suddenly, without any warning, become active. It is not an uncommon occurrence for such a sudden eruption to tear off and blow away the entire top of the mountain. This is what happened when Krakatoa exploded. Nor is there any way of telling when a quiet volcano is going to become active. It is true that rumblings and quakings of the earth usually precede an eruption and thus

tell us that there is danger of an explosion. But since such rumblings are not always followed by explosions, they are frequently looked upon as false alarms. As a result, people who live in volcanic regions do not always pay attention to them. Whole cities have been destroyed by volcanoes that suddenly became active after many years of quiet. After you have read about a few of the most celebrated volcanoes, you will understand better what it means when one of them becomes active.

Photograph by Underwood and Underwood
Mt. Vesuvius in Action

Mount Vesuvius in Italy is the most famous volcano in history. About two thousand years ago this volcano, which had been quiet for as long as the people could remember, suddenly came to life. It is true that, for a period of sixteen years preceding the great eruption, there had been rumblings and earthquakes in the region, but there had been no sign of activity in the volcano.

One day in the year 79 A.D. a terrible earthquake occurred and then great masses of dust, ashes, and rock were hurled from the mouth of the volcano. In a short time the entire sky for miles around became black, due to the volcanic dust and smoke which filled the air.

Around the base of the mountain were prosperous villages and cities, and the sides of the mountain itself were covered by beautiful homes and well-kept farms. All were soon buried under the masses of dust and cinders that poured from the volcano's mouth.

These materials fell so swiftly that not all the inhabitants were able to escape. Some of these unfortunate people have been found where they fell, clinging to the valuables which they were trying to carry away with them. The story is told of a Roman guard who, refusing to leave his post, was completely buried in a standing position by the rain of dust and cinders.

Two towns, Pompeii and Herculaneum, which were buried at that time, have been partially uncovered. We have learned much concerning the customs of the ancient Romans from what has been found buried under the ashes and cinders.

In 79 A.D. Pompeii was situated on the coast, but its old site is now a mile from the sea. This shows how a volcano can change the surface of the earth by pouring out great quantities of material from its interior.

Vesuvius has burst forth at intervals ever since its historic eruption, though at times several hundreds of years have elapsed between its periods of activity. The last time it became active was in 1906, when it destroyed a village and was responsible for the loss of many lives.

There is a volcano not far from our own country that burst forth in 1902 and destroyed 30,000 human beings. This volcano, which is named Mount Pelee, is situated on Martinique, one of the islands of the West Indies. Mount Pelee had been silent for almost a hundred years, save for the emission of a little volcanic dust and the occurrence of earthquakes about fifty years before. During the two weeks preceding the great explosion, rumblings were heard and a quantity of smoke and ashes issued from the mountain. Although a number of people who lived on the mountain side were killed and considerable damage was done to property, the inhabitants of the neighboring villages did not realize that they were in danger.

In May, 1902, however, the threatened eruption came. It was the most terrible explosion in the history of the western hemisphere. Tremendous quantities of volcanic dust and cinders, accompanied by poisonous gases and volcanic mud, fell upon the city of St. Pierre and the neighboring villages, completely destroying them. Every human being except one in the city of St. Pierre was killed. In the case of Mount Pelee it was probably the gas that was responsible for the great loss in human life. About two months after the great explosion, another occurred. While it was not so serious as the first, it did great damage to the region.

Volcanoes like Vesuvius, Mount Pelee, and Krakatoa, are said to be of the explosive type, because of the great explosions that occur at the commencement of an eruption. In some cases very little or no lava flows from the crater after the main explosion, but in others the flow extends over long periods. Sometimes the comparatively quiet flow of lava is

interrupted by explosions at irregular intervals. At other times gas, smoke, and steam issue from the crater between explosions in more or less steady streams.

There is another kind, however, that is very different. Here are found no great explosions, only a more or less constant welling up of lava through the crater or through cracks in the sides of the volcano. The well-known volcanoes in the Hawaiian Islands are of this kind.

Kilauea, on the Island of Hawaii, has a crater which is about three miles in diameter. This crater is filled with molten lava extending an unknown distance into the earth. The upper portion of this mass has hardened with here and there places where the molten lava can be seen. The surface of the lava mass in these places rises and falls from time to time a distance of several hundred feet. At times the walls of the volcano break away and allow hot lava to flow down the sides of the mountain. There is not much danger from a lava flow of this kind, unless the mountain is extremely steep, because it does not usually flow fast enough to prevent the escape of people in its path.

Volcanoes are not found in all parts of the earth. Most of them are located along the shores and on the islands of the Pacific Ocean. There are some, however, in the West Indies, Iceland, the regions bordering the Mediterranean Sea, under the oceans, and a few in the interior of the continents. There are about five hundred active volcanoes in the world.

In addition to the active ones, there are many more that have been quiet for centuries, and, as far as we know, will never come to life again. Some of these quiet, or extinct, volcanoes are in our own country. Mount Hood and Mount

Shasta are examples of extinct volcanoes. But no matter how quiet a mountain has been, it can never be trusted to remain so. Mount Lassen, in California, suddenly came to life in 1914. It is the only active volcano in the United States.

There are active volcanoes under the oceans. We have proof of this in the ashes and volcanic dust which once in a while appears on the ocean's surface in regions far from any known volcano. Furthermore, many islands, especially in the Pacific Ocean, are nothing more than the tops of volcanoes which have heaped up such huge quantities of lava and other material upon the ocean bed that these accumulations have risen above the surface of the water. The Hawaiian Islands are of this origin.

There are scientists who believe that in the early history of the world great masses of molten material were heaved up by numberless volcanoes and that the weight of this material caused the earth's crust to settle in large areas. They believe that these regions later became filled with water which now constitutes our oceans.

Whether or not these scientists are correct, we do not know. But we are quite sure that, since the beginning of human history, the work done by volcanoes in changing the surface of the globe is insignificant as compared with that done by the rains, the air, the wind, and the frost upon the surface of the land and by the sea upon the shore lines.

QUESTIONS AND TOPICS FOR DISCUSSION

1. Describe the eruption of Krakatoa in 1883.
2. What causes volcanic eruptions?
3. What may happen during the eruption of a volcano?
4. What characterized the eruption of Vesuvius in 79 A. D.?

5. In what respect did the eruption of Krakatoa differ from the eruption of Vesuvius?
6. What were the results of the explosion of Mount Pelee?
7. What can you say concerning volcanoes in the United States?
8. In what regions of the globe are active volcanoes usually found?
9. What part may volcanoes have played in the early history of the earth?
10. Describe the eruption of a volcano of the Hawaiian type.

GLACIERS AND WHAT THEY DO

One night in April, 1912, the Titanic, a great ocean liner, was steaming through the waves at full speed. Her searchlights playing upon the waters ahead revealed no danger. Suddenly there was a frightful crash that shook the ship from end to end. She had struck an iceberg that tore a great hole in her hull. Men and women, crazed with fear, ran to and fro, while the officers and crew did their best to reassure them and to maintain order. Meanwhile, water poured in through the hole which the iceberg had made, and, as it filled her hull, she began to settle more and more.

Knowing that the ship was doomed, the captain ordered the crew to lower the life boats. As fast as they were filled with passengers they pulled away from the sinking ship. In their mad efforts to get into these boats many passengers were drowned, and some of the boats which were overloaded went down beneath the waves. Lower and lower the great ship settled until, finally, she disappeared, carrying with her over 1400 human beings.

You probably wonder why you have been told about the damage done by an iceberg, when this chapter is headed "Glaciers." The reason is that an iceberg is part of a glacier. It is a fragment which has broken away from the main mass of ice and has floated out to sea.

Icebergs, as you can well believe after having read about the fate of the Titanic, are a constant source of danger to vessels passing through waters in which they are found. They have been responsible for the loss of unnumbered ships that

went to sea never to return. Before we tell you more about them we will explain the nature of glaciers and from whence they come.

The snow that falls in our part of the world disappears in the spring, but there are regions where the ground is covered by it all the year. The lands around the Poles and the tops of many high mountains have been buried under snow for ages. The largest mass of such land is the great Antarctic Continent around the South Pole with an area of five million square miles. The next largest is Greenland, in the North, with an area of nearly a million square miles. The Alps are the most famous mountains whose tops are covered with perpetual snow, but there are many others in the world.

The name glacier has been given to snow caps, such as lie upon the Antarctic Continent and Greenland, as well as to the moving masses of snow on mountains. We have spoken of a glacier as being composed of snow, although the greater part of them is ice. But our statement was correct, because ice is but one form of snow since it consists of snow crystals that are packed tightly together. But why is it that some of the snow takes the form of ice? It is due to pressure. At first, the snow from which all glaciers were formed was just like other snow and fell just as snow always falls. But, in the course of time, there was so much of it that the lower portions became packed into little grains that resembled sand. Then this sand-like snow, because of the heavy pressure from above, became (and still becomes, for the process is going on all the time) still more tightly packed and finally became solid ice.

Let us see why it is that glaciers in warm regions do not

melt in the spring. It is simply because the home of the glacier is always above the frost, or snow, line. If we climb a lofty mountain in any part of the world, even in the Torrid Zone, we come to a level where water freezes, since the temperature grows colder as we ascend. This point is called the snow line, for above it there are only snow and ice. Wherever there are hollow places above the snow line, on the sides of, or between, mountains where snow can collect, glaciers may form.

As you have learned, most of the snow that collects in such places turns into ice. Now ice, although a solid, is not rigid like stone or steel but, in large masses, moves, or "flows," somewhat as water does, only more slowly. So this mass of snow and ice which we call a glacier, pushed on by the weight of fresh snow behind and above, seeks a lower level, just as water does, and, in so doing, flows down a mountain valley. Its rate of flow is extremely low, being, on the average, only from one to four feet a day, though there are some glaciers that travel as much as fifty feet in a day. On the other hand, some move but a few inches in the same time.

When a glacier reaches the snow line it begins to melt, the snow on top changing to ice and water, and the ice underneath into water. It is at the snow line that the glacier really begins, but we frequently use the term to include the body of snow above as well.

When glaciers pass down crooked valleys and down steep slopes, cracks, called crevasses, often form in them, because ice does not take the shape of the surface over which it passes as water does. Many people from all parts of the world go to Switzerland every year to climb the glaciers. This climb-

Courtesy U. S. Geological Survey

CASCADE GLACIER, WASHINGTON

ing is dangerous work because of the crevasses, some of which are a hundred or more feet deep. All members of a glacier-climbing party are connected by a rope in order to prevent injury if any of their number should slip into a crevasse, but, in spite of this precaution, it sometimes happens that men do fall into crevasses and meet their death, sometimes even dragging others down with them.

Water from the melting surface of the glacier flows into these crevasses and down the sides of the ice mass, forming a stream that flows downhill underneath the glacier.

A glacier continues to flow down its valley until a point is reached where the amount of ice that melts in a certain time just equals the amount that is pushed forward in the downward flow during the same length of time. At this point, which is the foot of the glacier, or its lower limit, it comes to an end, and the stream of water flowing beneath it issues forth and continues as an ordinary river or a brook, depending upon the size of the glacier.

One would not be apt to think that ice, moving as slowly as a glacier does, could do very much work, but glaciers carry great quantities of material down the mountains, just as rivers do. Rocks and earth, loosened by the scraping sides of the moving mass, and falling upon it from the sides higher up, gather on its surface and are carried along with it. Many of the rocks, in the course of time, sink down into the ice and become a part of the glacier. Some of these rocks, embedded in the bottom and the sides of the moving ice, scrape away the materials lining the valley. Then, besides, rocks on the bottom and sides of the valley often become frozen into the ice and are also carried down with it. Thus great quantities of rock and soil pass from the mountain sides down to the end of the glacier. At this point the material piles up, as the ice containing it melts, and often forms a high ridge just below the end of the ice mass.

A glacier is usually said to be advancing or retreating, that is, its lower limit is not definitely fixed. It is either going forward, down the mountain, or, owing to its lower end

being worn away by melting, seems to be going backward, up the mountain. The glacier itself, of course, never moves backward, but the lower end, due to melting, is sometimes farther up stream than at others. The glacier advances, of course, when the temperature becomes lower, since, under such conditions, there is less melting. It retreats, on the other hand, with a rising temperature, for the opposite reason. While advancing, the materials being carried are deposited farther down the valley. With a retreating glacier, however, they are left nearer the frost line, as is being done at the present time in the Alps.

The rivers that flow from the lower end of a glacier bear much sediment which they carry to other places, just as ordinary rivers do.

There is another kind of glacier that is very similar to the Alpine glaciers just described though differing from them in the outcome. They are found where glaciers in their course pass down mountains into hollow places in the land, which they fill up. The mass of ice resulting is called a piedmont glacier, which means one that is situated at the foot of a mountain. Sometimes several different streams of ice assist in forming one of these glaciers. Piedmont glaciers are similar to lakes, the only difference being that the hollows are filled with ice instead of with water. They are sometimes called ice lakes, or lakes of ice.

Now that you know something about the glaciers that form in mountain valleys and at the foot of mountains in the warmer regions of the earth, let us examine the great ice caps that cover land masses like Greenland. This country is under an ice sheet that is probably several thousand feet

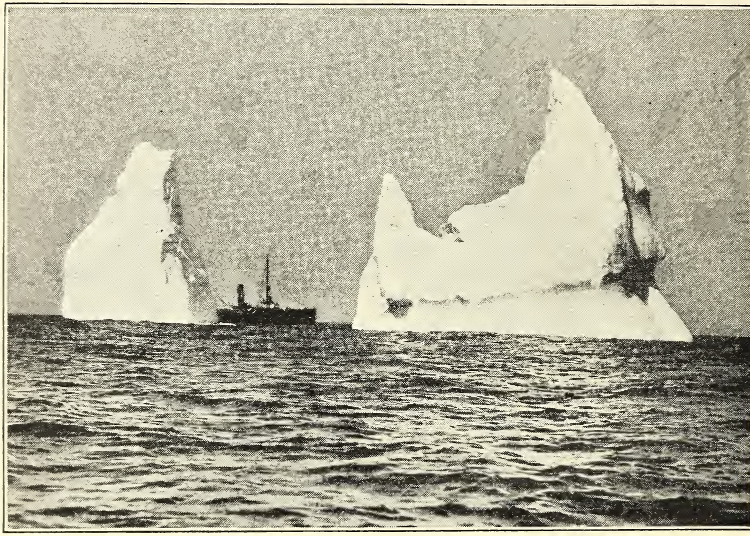
thick in places. It fills valleys and covers mountains making Greenland just one great stretch of fairly level ice with here and there a mountain top projecting upward.

Here is found the same sand-like snow on top with solid ice underneath, as was seen in Alpine glaciers, and, like the Alpine glaciers, this continental glacier, as such sheets of ice are called, is slowly moving toward the sea. In its passage it collects rock and other material from the land that it travels over, as do the Alpine glaciers, but since it flows over the tops of most of the mountains, very little material falls upon its surface. The glacier deposits the materials which it has collected at the continent's edge, and here and there rivers flow from under the ice into the sea where they, too, deposit their load of sediment.

When the glacier reaches the sea, its end does not fall off at once, but floats upon the surface of the water for a time, still remaining attached to the mass that has not left the land. But the ice projecting into the water is pounded by the waves and finally breaks off in huge lumps, forming icebergs. Icebergs thus formed float away, only about one-ninth of the mass showing above the surface of the water. You can easily see how deeply ice sinks into water by placing a small piece of it into a tumbler of water. Some icebergs are very large and project down into the water for several thousand feet. Usually they are much broader under water than above it. Ocean currents carry these icebergs to warmer waters where they rapidly melt and disappear. But while they are being borne along on the sea, they are a source of great danger to navigation. The smaller ones are particularly dangerous because they can hardly be seen in stormy weather and at night. The

Titanic, as has been seen, not many years ago ran into the hidden part of an iceberg and went down to the bottom carrying many hundreds of human beings.

Police boats now patrol the Atlantic Ocean in search of icebergs that float down from the north. When one is seen, the news is flashed by radio to other ships in the neighborhood and to all shipping centers along the coast. These iceberg patrols undoubtedly make ocean traveling much safer than it used to be, but they cannot entirely remove the danger, since it is impossible for them to cover all of the regions where icebergs are likely to be present.



Photograph by Underwood and Underwood

THE "SENECA" FINDS ICEBERGS IN PATH OF STEAMERS

At different times in past ages the northern part of our continent was covered by ice similar to that which now lies

upon Greenland. Some of these ice fields extended as far south as the Ohio River. After remaining for long periods of time these glaciers finally retreated, their lower edges traveling farther and farther to the north.

The same thing took place that occurs in the Alpine glaciers—great quantities of rock and soil were brought down and deposited as the ice melted. All over the northern half of the United States and over Canada are boulders and other kinds of rock and soil that were brought there by the ice sheets. There are many long hills and mounds that are formed of such material in various places in these regions. In the central part of New York State these structures are particularly numerous.

When such a glacier passes over the land, it frequently leaves masses of rock and soil across river valleys, thus damming back the water. In this way many lakes, like most of those in New York State and in Maine, came into being. Sometimes the material deposited dams up the natural outlets of old lakes and causes them to empty at some other place. This happened in the case of Lake Erie, for the last glacier closed its old outlet and forced its waters to flow over what are now Niagara Falls. Glaciers also frequently cause rivers to seek new courses, because the material deposited sometimes shuts off old channels.

Glaciers, similar to those which passed over our country, once covered Northern Europe, extending as far south as Germany. As a result of the presence of these ice sheets, the surface of that part of Europe was changed in ages past, just as was that of our own country.

There have been several glacial ages, that is, periods of

time when the great ice sheets crept down from the north. They were the results of changes in the temperature of the world, the causes of which we do not know. The last ice sheet retreated many thousands of years ago. Whether or not there will ever be any more we cannot tell, but even if there are, it will not be for many thousands of years, because the great changes in the climate which are necessary to produce them require the lapse of ages.

You have been told about the three different kinds of glaciers. The first kind, or the Alpine Glacier, is the result of the accumulation of snow above the frost line on mountains many of which are in warm regions of the earth. The second kind, or Piedmont Glacier, is produced by streams of ice which flow into hollow places at the foot of mountains, just as streams of water from lakes. The third kind, the Continental Glacier, is a great ice sheet that covers large tracts of land like Greenland or the Antarctic Continent. The ice sheets that lay upon the northern part of the United States and on Canada during the Glacial Periods were of this type.

The work of glaciers is very similar to that done by running water—they wear away land and carry it to other places. The main difference between them is that glaciers work much more slowly than does water. Glaciers can, however, do things that water cannot, like carrying great boulders long distances and building dams across wide valleys.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What is the origin of icebergs?
2. How much territory is covered by the great continental glaciers?
3. Account for the presence of glaciers in the Torrid Zone.

4. Describe the movement of an Alpine glacier.
5. What kind of work is done by Alpine glaciers?
6. What is a piedmont glacier?
7. Why are icebergs a menace to vessels?
8. How can one tell that a glacier has passed over a country?
9. How were many New York State lakes formed?
10. Compare the work done by a continental glacier with that done by an Alpine glacier.

OUR DISAPPEARING FORESTS

"This is the forest primeval. The murmuring pines and the
hemlocks,
Bearded with moss and in garments green, indistinct in the
twilight,
Stand like Druids of eld, with voices sad and prophetic;
Stand like harpers hoar with beards that rest on their bosoms."

Such was the scene that met the eyes of those who first settled our shores. The forests were indeed primeval, for everywhere, save along the sea coast, trees, hundreds of years old, untouched by the hand of man, reared their tops above the younger generations, while between them the ground was covered by densely growing vegetation.

Animal life was plentiful in those ancient woods, for the deer, the elk, and many other animals made their homes within them. In the trees birds of all kinds built their nests. Fish were abundant in the streams which never ran dry since they were fed by never failing springs. In those forests also dwelt the Indians who found in them food, shelter, and protection from the weather and their enemies.

Though the land as a whole was covered by forests, there were clear spaces here and there where the trees had been burned. Sometimes sparks from campfires were blown by the wind among the dry leaves. Since the Indians had no way of fighting the fires that resulted, great damage was often done to large tracts of timberland. But sometimes the Indians purposely set fire to the woods in order to clear the

land that they might have room for their dwellings and places where they might plant their grain. It is also said that at times they burned tracts of land so that they might pass through them the more easily on their hunting trips.

With the coming of the settlers, swift destruction of the trees began, for they, too, destroyed the forests so that they might have clearings in which to build their homes and places in which to plant their crops. They also cut the trees into timber which they used for building their homes, fences, roads, and countless other things. The result was that around each settlement the ground was gradually cleared of trees.

As the settlers came in greater numbers, more and more of the forests disappeared, and it was not long before but few of the virgin woods remained. Today our forests consist for the most part of trees that have grown up since the original trees were cut down. The work of destroying this second growth of trees and the virgin woods that still remain is going on rapidly. At the present rate of destruction, which amounts to many million trees each year, it will not be long before there are no trees left. Let us see why we are so wasteful of our natural resources.

In the early days of our country's history the people built most of their buildings of wood. And that is probably true at the present time, even though stone, brick, steel, and cement are now being used to quite a large extent, especially in the cities. But even when these newer building materials are used, much wood also finds its way into the construction of doors, window frames, floors, trimmings, etc.

At first the settlers employed nothing but wood for fuel, but later they began to use coal. For a long time, however,

their principal fuel was wood. Today, although coal, oil, and gas are our most important sources of heat and power, in some parts of the country large quantities of wood are still used for these purposes. The ties upon which the rails of our railroads rest are of wood, and so are most of our telephone and telegraph poles, our boats, our bridges, and thousands of other things. Boxes of all kinds require millions of feet of lumber. It has been said that half of all the timber that is cut is finally used for making them. This will not be difficult to believe when we take into consideration the large part that boxes play in the shipment of goods from one place to another.

Another use to which the trees are put is the making of paper. For this purpose wood is prepared in such a way that it resembles a thick paste, called wood pulp. In addition to paper, cardboard, building board, and similar products are made from this substance. For making these things, whole forests are destroyed each year. The men who cut timber to be used for wood pulp are very wasteful of the forests, because they use trees that are only a few inches in diameter. This means that the young trees are being cut down instead of being allowed to attain their growth.

In addition to the destruction of the trees themselves, their removal from the ground is doing untold harm of another kind. When we cut trees we prevent much of the rain which falls from remaining in the ground, because there are no roots and no thick carpet of leaves to hold the water. Consequently, most of it rushes down hill after every rainfall. In many places we have floods after heavy downpours of rain and when the snow melts in the spring. At other

times, the streams dry up because there is no water held in the ground to flow into them gradually. When all the trees have been cut from our hills, many of our rivers will be no longer useful for boat travel, because the water will be too low in dry weather and will rush downstream too rapidly in times of flood.

Another serious result from the loss of forests is the washing of earth from unprotected hills and its accumulation in the mouths of rivers where it interferes with navigation. Where there are no trees, the winters become colder and the summers warmer, because of the absence of the moisture held by trees which, when present, tends to prevent the occurrence of extremes in temperature. With the loss of the forests, many wild birds and animals, which, as you know, are important for human welfare, deprived of their food and the protection afforded by the trees, flee to other regions. This has happened in many parts of our country.

When the forests have disappeared, men are robbed of places to which they can go for pleasure and health. Now that more people live in cities than in the country, they need the forests more than they did when they were not so closely crowded together. Nothing can replace the restfulness, beauty, and health-giving air which trees alone can give.

In addition to the waste which results from the cutting of trees for useful purposes, much valuable lumber is destroyed by our carelessness. When cutting large trees we often let them fall on small ones, and sometimes we cut them too far from the ground, leaving the stumps containing valuable wood to rot. We at times use only the trunks, discarding great limbs which could be made into useful lumber.

Fire is one of the worst enemies of the forests. When timberland is cut, even if it is carelessly done, the greater part of the lumber is used, but when a forest burns all of it is lost. Forest fires result from several different causes. The carelessness of campers who leave smoldering camp fires is

Photograph by Underwood and Underwood

BURNT-OVER FOREST, GLACIER NATIONAL PARK

responsible for many. Cinders from railway engines frequently fall among leaves and underbrush and set them ablaze. Sometimes men and boys set fire to forests just to see them burn, or because they are angry with the owners of the land. Many fires are also caused by smokers who thoughtlessly throw matches and burning material among dry leaves.

The fall is the time of the year when most forest fires

occur. This is due to the dryness of the leaves which cover the ground at that season. It also happens that there are many hunters in the woods in the fall, for the fall is the principal hunting season. Besides the work of man, Nature kindles fires of her own. Some of our worst fires have been the result of lightning, and others have started from the heat produced by decaying vegetation. Forest fires do another kind of damage. Besides destroying timber they burn the materials in the soil on which plants live. This prevents the growth of vegetation in a burned region for a long time.

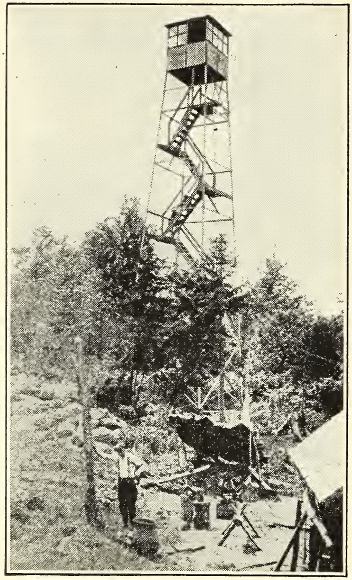
Centuries ago, men began to realize the value of the trees and took steps to protect their forests. Many European cities set aside great tracts of timberland and controlled the cutting. By seeing that new trees were planted in place of those that were cut down the people of these cities have maintained a regular supply of timber ever since.

Our country was late in taking steps to preserve our timberlands. Nothing important was done in this direction until 1877 when the Forest Service of the United States Department of Agriculture was established. This action was taken because the men at the head of our government realized that the people could not be depended upon to take care of the forests.

Scientists employed by many states soon made studies as how best to make use of the forests and how to protect them for the future. Through the advice and help which the states have given, many millions of trees have been saved from destruction. Many colleges and universities now give courses in forestry, which is the science that has to do with the preservation and best use of trees. Here men can learn the most

approved methods of lumbering and how to keep the forests in a healthy condition so that the future shall be provided for.

The United States government has set aside tracts of land, called forest preserves, in different parts of the country. We now have more than 150,000,000 acres of timberland thus protected, most of which is located in the Western states. In many regions men, called forest rangers, are employed to watch for fires. Some of these men are stationed on the tops of mountains in order that they may have a view over a wide stretch of land. In other places, tall steel towers are built for observation purposes. When these rangers see a fire anywhere in the forest, they immediately telephone other men whose duty it is to fight it. Air patrols assist in this work in both the United States and Canada. Many fires are thus put out before they have a chance to do much damage.



Photograph by Wide World Photos
Fire Patrol Observation Tower

In some states locomotives that pass through forests are compelled by law to burn oil instead of coal during the time of the year that there is danger from fires. There is not very much danger from oil-burning engines, because there are no cinders to fall among the dry leaves. Sometimes where

coal-burning engines are permitted, the engines are so equipped that the cinders cannot fall on the track as they ordinarily do. New York State is one of the states which has almost entirely removed this source of danger.

The regulations governing forest preserves also provide that trees shall be cut only under certain conditions, and that the greatest care shall be given that new trees are planted.

Several different methods of providing for the forests of the future are followed. In some cases, instead of cutting all the trees in a given region, only certain patches are cut at a time. Then the next year the trees are cut from another patch. This process is continued, a new patch being cut each year, until they have all been cut. By this time, perhaps the small trees left in the first patch will have had time to grow large enough for use. If so, the patch is cut again, and then the other patches in the order of the first cutting. At each cutting only the larger trees are taken, and precautions are used against injuring the smaller ones when the large ones are being felled. This latter program is now almost universal.

Sometimes the trees in a forest grow far apart. In such places new trees are planted between them, so that when the large ones are cut there will be others that can be used later. When such trees are planted, they are usually placed close together. Then as they grow larger the weakest ones are removed, which leaves a healthy crop of young trees to replace those which are cut. In some cases trees that are of no great value are cut down, while others that make better lumber are planted in their places. Sometimes trees that take a long time to grow are replaced by others that grow rapidly.

There are millions of acres in our country that have been burned over, and other millions that show only the stumps of trees that have been cut. New forests are being planted in these regions.

Thus we see that much is being done to provide for the forests of the future, but much still remains to be done. The government has no control over wasteful lumbering and carelessness in the case of privately owned forests. Many men are in such a hurry to make money from the trees that they care nothing for the welfare of succeeding generations. Such men do not guard the young trees, nor do they plant new ones. The help, not only of the states and the national government, but of everybody who has anything to do with trees, is necessary if we are to have any forests in the years to come.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What can you say concerning the condition of the forests of this country when first settled?
2. What are some of the uses to which wood is put?
3. What happens when all the hills of a given region have been cleared of trees?
4. In what ways are lumbermen sometimes wasteful?
5. What are some of the causes of forest fires?
6. What has been done by our government to safeguard our forests?
7. What steps have been taken by some of our states to preserve their trees?
8. During what season of the year are forest fires most numerous? Why?
9. How may forests be cut and the trees of the future still be provided for?
10. Why are we so wasteful of our trees?

THE DISTRIBUTION OF ANIMALS

Every year the American Museum of Natural History sends scientists to various parts of the world to study the forms of animal life peculiar to those regions. Sometimes these expeditions penetrate tropical jungles, sometimes they visit the frozen polar regions, and sometimes they examine unfrequented portions of the oceans. In fact there is scarcely a part of the earth that these searchers after knowledge have not visited. Of this nature were the expeditions made by Theodore Roosevelt up the River of Doubt in South America, by Carl Ackeley into the heart of Africa, and by William Beebe to the Sargasso Sea.

The study of animals carries us to all regions of the earth, because they are not uniformly scattered over its surface. Though they are numerous in some regions, they are thinly distributed over others. But there is no portion of the globe from which they are entirely wanting.

In some parts of the world, although similar in climate to other parts, entirely different species of animals are found. For instance, Asia and Africa are the homes of the elephant, the gorilla, the camel, and the hippopotamus, while there are none of these animals in South America. The latter continent, on the other hand, is the home of the llama and of the sloth, not found in Africa. The lion, the rhinoceros, and many other animals which are plentiful in Africa are not to be met with in Madagascar, an island situated near the continent. Yet the lemur, similar to the monkey, occurs in great numbers on the island, though it is extremely rare in Africa.

Other animals occupy regions that are separated by the oceans. The tapir which is found in South America lives also in the Malay Peninsula, situated on the opposite side of the globe. The same thing is true with respect to the bird life

Photograph by Publishers Photo Service
THE DAY'S END IN THE SAHARA

of England and Japan. An Englishman listening to the birds of Japan might well imagine himself back in England, for the same species are found in both countries. The reindeer of northern Europe and the caribou of Canada are alike, save that the caribou is larger in size. From these facts it is clear that the distance between bodies of land has very little to do with the types of animals living upon them.

Before we try to account for the way that animals are scattered over the earth, let us see what causes them to travel from one place to another, how they travel, and what hinders them from being equally distributed.

The principal reason why animals seek other homes is the need of food. It may be that animals of a particular kind become so numerous that there is not enough food to go around, or it may be that stronger or more numerous animals take their food from them. In other words, the struggle for existence, or the fight to keep alive, forces some of them to seek other lands.

Sometimes the scarcity of food is brought about by changes in the climate. Such a change occurred thousands of years ago when our country became so cold that ice lay over the Northern States the year round. This condition forced many animals to travel southward. They might have been able to endure the cold, but they could not live in their old homes because the change in temperature had destroyed their food.

When animals pass from one locality to another they are said to migrate. Migration may mean the moving of a group into a new region; it may mean the simple spreading out into new territory, or it may mean the traveling of individuals southward in the spring and northward in the fall.

The migration of a little rat-like animal, called the leming, in northern Europe is an example of the movement of a group of animals into a new region. Thousands and thousands of these little animals, in search of food, occasionally travel to the ocean, eating everything that is in their way. In columns a few feet apart, like soldiers on the march, they pass over

hills and through valleys, through lakes and rivers, until they reach the sea into which they plunge and drown.

Another animal which sometimes moves in the same way is the field mouse. These animals, which are of the same family as the leming, collected in great numbers in the Humboldt Valley, in Nevada, in 1906 and 1907. It is said that in some places 10,000 of these mice could be found on a single acre of land.

But migrations such as these of the leming and the field mouse are not very effective in spreading animals over the earth, because the individuals migrating usually perish, since conditions in the new regions are as a rule unfavorable.

The second kind of migration, that is, the simple spreading out into new territory, sometimes called normal migration, is very important since all creatures take part in it. It is only natural that animals should go into new regions in search of food, to find mates, and to escape from their enemies. The movements of the common potato beetle is an example of migration of this sort. This beetle, less than a hundred years ago, lived only in the western part of our country. It was not found east of Kansas, because its natural food, the wild potato, did not grow east of that state. When the population spread westward the cultivation of the ordinary potato went with it. The potato beetle began to thrive on this new food, and before long had spread all over the country as far as the Atlantic Ocean.

Another example of the effect of food supply upon the extent of territory occupied by certain animals is seen in the migrations of the fox squirrel. Until 1907 this animal lived, in northwestern Iowa, only in the timber lands along the

streams. Since then the prairie lands of that region have been planted with trees, and this squirrel has spread into the new forested region.

We believe that it is due merely to spreading out into new territory, usually in search of food, that certain species are found on opposite sides of the earth. Long ages ago camels, whose original home was probably in America, passed in search of food into Asia over a land bridge which connected that continent with Alaska. For the same reason, elephants migrated from Africa to Asia and lions from Europe into Africa.

We have been talking about the movements of animals that have permanently left their abodes. Now let us consider those that change their residence each year.

You know that many birds, living in countries which are cold during part of the year, annually travel southward where they remain until the winter is over. The American golden plover, for example, travels from the Arctic Circle as far south as Argentina in the fall, and in the spring returns to the place from whence it started. Another bird which travels long distances is a species of cuckoo which flies from the Fiji Islands to New Zealand, a distance of 1500 miles. Every one is familiar with the robins, ducks, and geese that leave our northern latitudes each fall for southern regions.

In this country the bison, or buffalo, when they ran wild over the plains traveled to warmer regions each fall, just as the caribou in Canada do today.

The sea offers some of the most interesting examples of seasonal migration. The herring swim to shallow water when it comes time to lay their eggs, and salmon leave the ocean

and ascend streams for the same purpose. Some fur seals travel each year as far as 6000 miles to Pribilof Islands in the Pacific Ocean, and the eels of the world pass at certain times to a spot not far from the West Indies where they lay their eggs and die.

Though most of the movements from one part of the world to another are the result of migration, some animals are transported to other regions by forces over which they have no control. The principal forces that bring about this result are the winds, the waters, and other animals.

Insects that are unable to fly more than short distances are sometimes carried hundreds of miles by the wind, and even small birds and bats have been borne by the same means to distant continents. But far more important as carriers of animals are the rivers and the oceans which transport not only full-grown animals but the eggs and the partly developed young.

The jellyfish and similar forms of life which do not move very swiftly are carried by the ocean currents from one part of the ocean to another. The eggs of fishes are transported far from the point at which they are laid, and the young of the lobster are borne considerable distances from their original homes.

Sometimes a mass of driftwood breaks loose from the shore on which it is formed and bears animals that live upon it to distant lands. By this means snakes, monkeys, and many other forms have been carried to new regions. Blocks of floating ice and icebergs also aid in scattering animals over the earth.

Species like the flea which live on other animals are fre-

quently transported by them to distant regions. The young of certain kinds of clams attach themselves to the gills of fishes and are thus carried to new waters. Man has had a great deal to do with the scattering of animals over the earth. He carried the jungle fowl of India, which later developed into the domestic hen, to all parts of the world; and he has transported the horse, the cow, and almost all of the other domestic animals to the ends of the earth.

Since there is such a strong tendency for animals to spread out over the earth, why is it that all forms are not found in every region? There are several conditions which interfere with such free movements. We call them barriers.

Among the barriers, climate is the most important. Certain forms of life are unable to live where the temperature falls below the freezing point, while others cannot live where the temperature is high. The frog and the alligator are unable to exist near the poles, while the polar bear cannot live in the Torrid Zone. Some animals, however, are but little affected by differences in climate. The elephant thrives from India to Manchuria and the tiger from Africa to Siberia. Besides, many animals, like the lion, originally came from northern latitudes and settled in the torrid regions of Africa.

The lack of moisture produces deserts that act as barriers over which few animals can pass. In Africa the Sahara Desert has kept the deer from leaving the extreme northern border of that continent. There are, therefore, no deer in its central and southern portions.

High mountains sometimes prevent migration of animals. This is particularly true when they lie east and west as the Himalayas do across northern India. Here the land at the

north of the mountains is much cooler than that at the south of them and is, therefore, populated by an entirely different kind of animal. When mountains run from the north to the south the condition is different. The animal life at the northern end of the Andes Mountains in South America is similar to that found at the southern end. The reason for this is that there is no barrier which separates the warm from the cold regions.

The seas prevent most animals from passing from one body of land to another. However, there are some forms, like the seal and the walrus that can move great distances through it because they have been accustomed to life in the water. Some land animals like the wolf and the bear can swim

Photograph by Publishers Photo Service

Walrus on the Ice and in the Water

considerable distances, but they are unable to pass across the ocean. There are certain wingless birds, like the kiwi of New Zealand, and others, like the ostrich, whose wings are too small for flight, that are unable to leave their homes. Almost all other birds can pass over the seas.

The salt waters of the oceans also prevent most fresh water fishes from moving to other localities. There are certain species, though—the salmon, the sturgeon, and the eel—that can live in both salt and fresh water. The oceans, therefore, do not keep them from passing from one region to another.

We have reason to believe that the distribution of animals in the past was far different from what it is today. Even in our own country fossils of camels and elephants have been found, showing that these forms of life, which are limited at present to Asia and Africa, once made our country their homes.

We believe that there was once a land bridge between Asia and Alaska, and that animals passed freely between these countries. We also believe that at one time North and South America were not connected by the Isthmus of Panama, because there is proof that this isthmus was at one time under water. Furthermore, there are many people who think that Africa and South America were once connected by land.

Why is it that if animals once lived in these regions they no longer live there? The answer to this question is long and difficult; in fact no one knows all the reasons why animals cease to live in certain territories, but we know some of them. Changes in temperature have prevented the growth of food that is needed by some; enemies, including man, have driven

others from certain regions, and disease has also played its part.

Even in our own day great changes have taken place in the animal populations of some parts of the earth. As the human population of a territory increases, the wild animals migrate to other regions or are killed by the new settlers. The settlers often bring with them domestic animals like the cow, dog, and horse. So you see the entire character of the animal life of a given region may change in a very short time.

But other changes in animal life can be seen besides those produced by migration and destruction. The alligator lives in two parts of the world. One group is found in Asia and the other in the southern part of the United States. These two groups are not exactly alike and are therefore called different species. When groups of animals, like these, belonging to the same family though differing from one another, are found in different parts of the earth, one, or perhaps both, has changed, during the course of time, and is no longer like the distant parents from which both sprang.

This kind of change, which we call evolution, has taken place and is taking place in all forms of life and will probably continue to do so as long as there is any life on the globe.

QUESTIONS AND TOPICS FOR DISCUSSION

1. How do South America and Africa differ as to the animals inhabiting them?
2. What may interfere with the food supply of animals?
3. What are the different kinds of migration?
4. Describe the migration of the leming; of the field mouse.

5. What type of migration is the most effective in the spreading of animals over the earth?
6. How far do birds sometimes migrate?
7. What sea animals migrate from place to place?
8. By what means are animals carried from one locality to another?
9. What features of the earth tend to prevent migration?
10. What are some of the causes of the disappearance of animals?

Within our own country great differences are to be seen in the kinds of lives led by people occupying dissimilar regions. The Seminole Indians of Florida dwell in the Everglade Swamp, hunting and fishing; in the West, cattlemen lead lonely lives on the plains tending their herds; while the dwellers of cities are engaged in all manners of occupation.

The same thing is true of the world as a whole. There is little resemblance between the lives led by the inhabitants of England and those of the Fiji Islands. The English follow modern pursuits, while the Fiji Islanders still cling to many savage customs. Likewise, the Japanese are progressive, while the people who live in the interior of China follow customs practiced by their ancestors of a remote past.

Besides the differences in manners, customs, and occupations, the various parts of the globe differ greatly as to density of population. The British Islands and New England are examples of countries which are thickly populated, while northern Canada and Siberia have very few inhabitants per square mile.

There are many reasons why man's activities should be influenced by the location which he occupies, and why certain territories should be more thickly populated than others. Among the various factors, climate is the most important, because it enters into every phase of his life. In the first place it determines where he may or may not live.

The Polar regions are unfavorable to human life because of the difficulty of getting food, since there is practically no

vegetation and almost no animal life where it is extremely cold. Furthermore, the human body is not adapted to very low temperatures. The Sahara Desert and part of the Arabian Desert, on the other hand, are equally unsuited to human habitation. In addition to the scarcity of plants and animals for food, the intense heat of the sun and the absence of water are reasons why it is difficult for man to exist in desert areas.

On the other hand, there are regions where the temperature is favorable to human life. They lie in the temperate zones, and in them dwell the greater part of the inhabitants of the earth. Here we find Europe, part of Asia, Australia, and the United States.

Between the extremes just mentioned and the regions favorable to man, are countries a little too cold or a little too warm for human beings to live and achieve their best. Northern Canada and Siberia represent countries that are too cold, while Central Africa and parts of South America those that are too warm. It is true that people are found in some of these regions, but not as many as in others.

Climate, besides determining where a man shall dwell, also determines how he shall live. In the cold countries, he is forced to cover his body with wool and fur and to construct warm dwellings. Since food is scarce in such places, he is forced to spend much of his time searching for it. Where the temperature is high, he wears almost no clothing and needs shelter only from storms, the heat, and from his enemies. Since there is an abundance of food in warm latitudes, he has to spend very little energy in search of it. The natives of the tropics devote a large part of their time to eating and sleeping.

In the temperate zone, man needs light clothing in summer and warm clothing in winter. He requires dwellings that will protect him from the intense cold in winter and from the heat and storms in summer. Food is not as scarce as it is in

Photograph by Underwood and Underwood

ESKIMO CHILDREN EATING CRABS

the cold regions, nor as plentiful as it is in the tropics. He must gather enough during the warm season to carry him through the winter. The necessity of providing for the future causes him to lead an active life.

Since the climate of temperate countries is favorable to man, he is more vigorous and healthy in such regions than he is in the frigid or the torrid zones. The temperate zone is, therefore, more suited to farming, manufacture, com-

merce, and all other activities that require the expenditure of energy. It is in the temperate zones that the greatest achievements of the human race have been seen. It is here that the most famous men of all ages have lived.

But the different parts of the temperate zones vary among themselves as to the character of their inhabitants, according to climatic conditions. Where there is a proper degree of moisture and frequent storms, as in England and parts of Japan, the people are more energetic than they are where the air is drier and the temperature more uniform. The same variations are to be seen in the frigid as well as in the torrid zones.

Though climate is the most important factor in determining where man shall live and in moulding his activities, there are many other forces which exert a powerful influence upon him. Among these factors are the presence of bodies of water, the degree of elevation above the sea, the kind of soil, the presence of minerals, the nature of the vegetation, and the type of animal life. Let us see what these factors have to do with man.

It is said that the land lying between the Tigris and Euphrates Rivers was the cradle of the human race: that is, it is the place where the first people concerning whom we have any authentic information lived. Another very ancient civilization was that in Egypt which occupied the land bordering the Nile River. Some historians think that the Egyptian civilization was older than that which occupied the Tigris-Euphrates Valley. Of that we are not sure, but we do know that the first people of whom we have records lived near rivers.

In our own day the greatest gatherings of human beings are found near bodies of water, principally near the mouths of rivers emptying into the ocean. London, Canton, and New York, three of the greatest cities in the world, are so situated. But there are many great inland cities located on rivers and lakes, like Chicago and Paris. Some of the reasons why people gather in large numbers near bodies of water are the advantages which the water offers for the carrying on of trade and hence the procuring of food, clothing, and other necessities and luxuries. The presence of water power furnished by rivers, and their use as a convenient means of disposing of sewage are other reasons.

The customs and activities of people living in these great centers of population are necessarily very different from those of people who dwell in thinly settled areas. Manufacturing and commerce become the main pursuits, but every form of industry and every vocation and profession are to be found here. In these centers, the arts and sciences find their greatest opportunities, as do all forms of education. Here are to be found the extremes of poverty and wealth as well as of ignorance and erudition.

The nature of the land occupied by people is, as has been said, an important factor in determining the character of their occupations. Those who live on fertile plains lead an agricultural life because of the ease of raising crops. Fertile land is also suitable to the raising of cattle and other domestic animals. Such lands are therefore usually occupied by an agricultural or by a cattle-raising community as contrasted with the manufacturing and commercial population found in cities.

Mountainous regions as a rule are thinly populated, because of the limited opportunities for making a livelihood. The main reason for this is the lack of satisfactory roads and the difficulty of transporting material even when roads are present. This is particularly true in countries traversed by mountain ranges, like the Andes in South America, where burros and llamas are used for this purpose. Agriculture can be carried on in such regions to a limited extent only, because of the unfavorable nature of the ground. Mountainous countries, however, are often suitable for raising cattle, though lumbering and mining are the principal occupations followed by those who dwell on mountains.

Photograph by Underwood and Underwood

Cattle Raising in the Wyoming Rockies

Mountain people are more hardy than are those who dwell on plains, because only those who are able to withstand great privations and undergo severe hardships are able to survive. Besides, the outdoor life which such peoples lead tends to give them robust bodies. The Highlanders of Scotland and the Swiss are as a rule strong and healthy for these reasons. The history of the world is full of instances where sturdy mountain folk descended upon lowlands, the inhabitants of which had become weakened by a life of ease, and conquered them.

There is a tendency for those who dwell on mountains to stay by themselves, and to advance less rapidly in civilization than the peoples who live where it is easy for one group to communicate with another. This is true of the tribes that dwell in the Caucasus Mountains, and has been true even of our own country, especially in the South.

Lumbering has been mentioned as being one of the activities carried on by mountain peoples. This industry, however, is not confined to mountainous countries, since there are great timberlands on plains and in valleys. Lumbering attracts men to such regions as Northern Canada and Central Africa which otherwise would not be inhabited.

As with lumber, so it is with minerals. Mines are often situated far from the ordinary haunts of man. Large settlements sometimes grow up around such mines as are found in the Lake Superior region and the gold fields of the United States.

Whenever valuable metals, petroleum, or precious stones are discovered in a certain locality, hordes of men hurry thither. In some cases cities have sprung up, like those

which resulted after the discovery of gold in California in 1849. But large collections of people due to this cause are not, as a rule, permanent, because men who fail to "strike it rich" usually soon depart, leaving only those who can make a living in the mines or in industries connected with them.

Certain parts of Pennsylvania are settled by large aggregations of people attracted by the mining industry, since some of the largest mines in the world are situated in that state. The discovery of petroleum in Oklahoma made great changes in the population of certain localities in that state, because thousands of people from other states migrated to the oil fields and settled there.

In addition to mountainous regions, there are portions of the globe that are not adapted to the raising of grain, but which will grow grass suitable as food for domestic animals. On such land we find great herds of horses, sheep, and cattle. The great grassy plains of the western part of our country are of this nature. Land of this kind is peopled principally by men who are engaged in cattle raising.

Wild animal life also has its influence in attracting people to various parts of the earth. This is true because each kind of wild animal that is sought by them occupies a particular kind of territory. Fishermen dwell along the coast of Newfoundland, and hunters and trappers make their homes in Siberia.

Certain forms of animal life render some regions unhealthful to live in. The white man cannot successfully live in a region which is infested by the yellow fever mosquito. The plagues resulting from the presence of such

insects are being overcome in some localities, like Panama, for example, by keeping these insects in check. But there are still many regions unoccupied by the white man because of their presence.

It can thus be seen that the distribution of man upon the earth is dependent upon many factors. These factors also aid in determining the kind of life he shall lead. Since his location on the globe influences his activities, it also influences his needs. People who live in great groups have more wants than have those who dwell in less thickly populated places, because life is more complex under such conditions.

Commerce, manufacturing, education, religion, and every other activity and interest of man is dependent, to a greater or less degree, upon the place in which he lives.

We have told you some of the reasons why certain parts of the earth have many inhabitants and some only a few, and how the lives of certain groups of men are influenced by the places in which they live. But we have made no attempt to cover the subject completely. It would take many volumes and more knowledge than any one man possesses to do so.

QUESTIONS AND TOPICS FOR DISCUSSION

1. Why are some regions of the earth more thickly populated than others?
2. Discuss climate as a factor in determining human habitation.
3. How does climate affect man's mode of living?
4. What relation do rivers bear to density of population?
5. What kinds of industries are usually found in river valleys?
6. What occupations are found in mountainous countries?

7. What relation do minerals bear to population?
8. How may animal life influence man to live in desolate regions?
9. What kind of land is most likely to be populated by hardy peoples? Why?
10. In what zones would you expect to find the greatest manufactures? Why?

THE STORY OF TRANSPORTATION

A hundred years ago it took a stage coach about a week to travel from New York to Albany, 150 miles away. In the spring of 1928 an Englishman drove an automobile over a Florida beach at the rate of 206 miles an hour. Had the stage coach traveled at the same rate it would have reached Albany in less than an hour.

Like everything else in the world, the development of transportation has been a slow process. It has been only within the past hundred years that anything approaching modern efficiency in carrying people and things from one place to another has been achieved. Let us review the various steps which have marked the progress of transportation from its simplest form to its present status.

Man-power is the simplest means of transportation and also the oldest. For ages, in the early history of man, it was likewise the only means. Even the great blocks of stone of which the Egyptian pyramids were built, many centuries ago, were transported by man-power. They were either carried or hauled great distances through the sandy deserts, and by hordes of human beings. There was then no other way. The North American Indian, too, carried his goods on his back or in his canoe which was propelled by hand.

In spite of the fact that man-power is the oldest means of transportation, it is, because of its simplicity, still used in all parts of the world. Advances and improvements in the methods of transportation have not always been followed by the dropping of those that preceded. The Chinese coolie

still serves as a bearer of burdens, and even many an American laborer continues to carry his load on his back. Side by side, the railway locomotive and the man with a pack are now daily doing their work.

Long ages ago certain individuals saw the possibility of using some of their tamed animals for carrying their burdens. In various parts of the world, different animals were employed. In the far East, the elephant was found to be suited to this purpose. In the desert, the camel became the means of conveyance. In other regions, the horse, the llama, the ox, and even the dog, were taught to do this work. And, as we saw in the case of man-power, these animals are still utilized where other means are wanting and where other means would be of little use. It would be impossible for an automobile or other machine to pass over the rough trails which cross the Andes Mountains. The camel is still the best agent for carrying goods through certain deserts which are inaccessible to other animals and to man-made machines. The horse still finds work to do in countries where the automobile is in the ascendancy.

Early in the history of our own country the pack train gave way to the wagon train. Prairie schooners, or covered wagons, constituted the principal means of conveyance across country for many years. While they were laboriously traveling through the wilderness, the stage coach was carrying people and goods in the more settled regions. Regular routes were established between the principal cities of the eastern part of our country. Travel by stage was a tedious process. It required more days to travel from Boston to New York than it now does to go to Europe.

But before long a speedier means of travel was established, for the steam engine came upon the scene. At first, running upon wooden rails and burning wood as fuel, it rattled along at a pace not much faster than the stage coach. Traveling was still a difficult undertaking, for the imperfections of the first steam engines resulted in frequent breakdowns and delays. But gradually the wooden rails were replaced by steel rails, and coal and oil supplanted wood as fuel. Today, our giant engines can carry heavy trains from New York to Chicago in eighteen hours, and they can travel from coast to coast in less than four days.

For travel within our cities and between them, cars driven by electric power are used. The trolley car and third-rail train are familiar to all. In some cities underground electric roads, known as subways, and overhead roads, known as elevated roads, make quick transportation possible. The electrically driven engine is also appearing in place of the steam engine on many of our railroads.

The railroads have made it possible for people to live together in large numbers in cities like New York and London. Where several million people dwell within an area of but a few square miles tremendous quantities of food must be carried to them daily or they will starve. This the railroads do. The gigantic strides in industry made by the world during the past century could not have been made without the railroads, because without them necessary commodities could not have been transported from place to place with sufficient speed.

Another mode of conveyance, which has had an even more remarkable development than the steam and electric

engine, is the gasoline-driven automobile. This machine, in some places, seems to be supplanting the older means of conveyance, not only in the transportation of passengers but of goods of all kinds. The auto truck carries its load of freight hundreds of miles, and the touring bus makes regular runs between cities and towns. The farmer now carries his food to market in his auto truck, while the dealer delivers his commodities to the farmer in the same way. Practically all the delivering of goods in cities and towns which was formerly done by the horse is now done by the automobile. In 1926 there were over twenty-two million automobiles in the United States. At the beginning of the century there were relatively very few.

Having traced the changes that have occurred on land, let us see what has been done on water. Ages ago, untutored man poled or paddled logs and rafts. Then, by hollowing out a log, he made a dugout, and by covering a wooden framework with bark he made a bark canoe. At first he used paddles, later oars. The Romans and other ancient peoples propelled large crafts by means of oars. Sometimes they employed several hundred oars, arranged in tiers one above the other. These boats were called biremes or triremes, depending upon whether there were two or three tiers of oars.

After man learned how to construct boats, it was not long before he began looking around for other sources of power than lay in human muscles. The wind was the first that attracted his attention. At first he made simple sails that were used only in traveling before the wind. Later, from this primitive sail boat, he developed large craft that had great

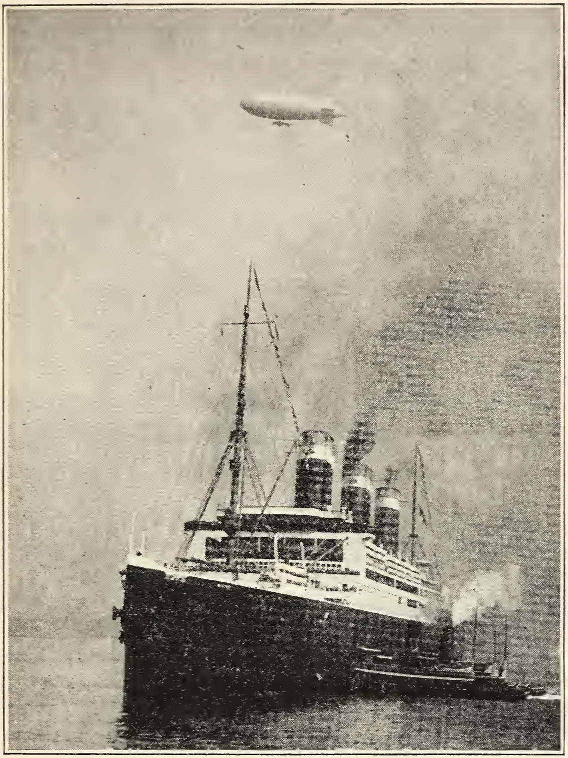
speed and could travel in any direction except directly against the wind. For a long time sail boats were the only means that man had by which he could make long voyages. In them he was able to travel around the world. It was in sailboats that Columbus and his followers made the first voyage to America.

With the invention of the steam engine, a new era in navigation began. In 1790 a man named Fitch constructed a passenger boat run by steam, but it was unsuccessful because his crude engine took up too much room. In 1807 Robert Fulton made his famous voyage up the Hudson River, from New York to Albany, a distance of 150 miles, in 36 hours. This was the real beginning of steam navigation. The first steam boats had revolving paddle wheels one on each side. These side-wheelers were never able to go very fast, but they were very satisfactory for ordinary traffic. They are still in operation in various regions of the earth.

While the steamboat was being perfected, other boats were being hauled across the land through canals which had been dug for them. They were towed by horses and mules that traveled along the banks of the canals. Later, in progressive countries, the horses and mules were superseded by steam engines as sources of power for these craft. But horse and mule-driven canal boats are still used in certain backward localities.

As new discoveries were made by science and faster means of water transportation were required, the side-wheelers gave way to boats that were propelled by revolving blades in the stern. Many modifications have been made of this improved means of driving craft through the water.

Our modern ocean liners, propelled by revolving blades in the stern, are able to cross the Atlantic ocean in four and one-half days. These great ships, equipped like the most



Photograph by Underwood and Underwood
LEVIATHAN AND DIRIGIBLE

luxurious hotels, carry thousands of people in comfort. Modern freighters can carry thousands of tons of merchandise to the most distant parts of the globe in less time than it took a Roman trireme to cross the Mediterranean Sea.

But far swifter than the steam-driven ocean liners are boats driven by gasoline engines. A speed of eighty miles an hour was achieved by a gasoline motor boat in the spring of 1927. If the gasoline engine could be used in ocean liners it might be possible to leave America one day and to arrive in London the next.

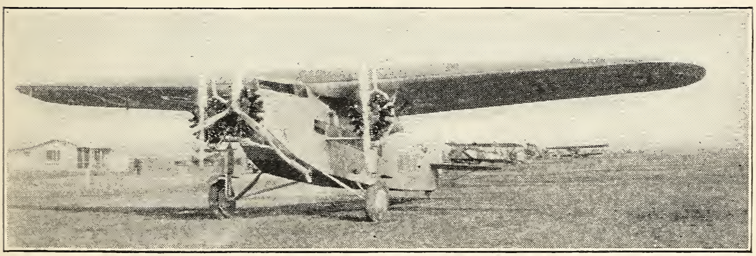
We have considered the advances in transportation which have been made in boats that float on the surface of the water. The submarine, which travels beneath the surface, must not be forgotten. This craft is used almost entirely for war purposes; however, it is sometimes employed in carrying merchandise. To what extent the submarine will be used for purposes not connected with war remains to be determined.

Now let us see what has happened in the air. The balloon, filled with hot air or a gas lighter than air, was the first apparatus made by man that could travel above the earth. It was of little use for a long time because it could not be guided. It drifted whither the wind carried it. One of its principal uses was that of making observations in time of war. Not many years ago the skill of the scientist made possible the construction of a balloon which could be directed at the will of the operator. Balloons of this type are called dirigible balloons. Regular schedules are followed between certain European cities by these balloons which are engaged in passenger and freight traffic. The part that these air-going ships played in the World War is well known.

But by far the greatest advance in aërial transportation has been made by the airplane. Here again we see the

achievement of the gasoline engine. The terrific speed necessary to keep these heavier than air machines afloat was not possible until the gasoline engine was invented. The airplane is therefore, like the automobile, a twentieth-century institution. It is in its infancy, but improvements are being made in it every year. The possibilities in connection with the airplane were brought to the attention of the public during the World War. The ease with which it was manipulated and the speed with which it traveled made it evident that it could be utilized in time of peace for numberless purposes. Even now it is being put to commercial uses of great importance. It is used to transport passengers both in Europe and in our own country. Schedules as regular as those of steam roads are followed. Travel by airplane is as comfortable and almost as safe as that by other means of conveyance.

We now use the airplane for fast-mail delivery. There is a coast-to-coast service which is maintained summer and



Courtesy Atlantic Aircraft Corporation

THE FOKKER F-VII TRI-MOTOR AIRPLANE

winter. It is very seldom that the aviators in this service experience a mishap, so reliable are the machines which are now being built. The tri-motor Fokker, shown in the accompanying illustration, is a popular machine in this service.

In May, 1927, Lindbergh flew from New York to Paris in thirty-three and one-half hours. His flight marked the beginning of a new era in aërial navigation. Almost immediately Chamberlin's plane carried him from New York to Germany. The Atlantic Ocean seems no longer to be a barrier to aërial travel.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What animals have been used for carrying burdens?
2. What were the means of transportation employed in the early history of our country?
3. What effect has the steam engine had upon the growth of cities?
4. How has the gasoline engine influenced the life of man?
5. How many automobiles were there in the United States in 1926?
6. Give the early history of navigation.
7. Who were the inventors of the steamboat?
8. For what purposes is the submarine used?
9. To what extent is the dirigible used for transporting men and merchandise?
10. Why was the invention of a practical airplane delayed until the invention of the gasoline engine?

TEN YEARS IN THE AIR

The World War taught students of aviation important lessons. The various uses to which air craft were put, as reconnoitering, fighting, and carrying messages and supplies necessitated machines of different types. The result was that at the close of the war there were facilities at hand for the building of air ships of many models and there were many men skillful in their construction and operation. Furthermore, the war had shown wherein they were strong and wherein they were weak. This knowledge led to many improvements in machines that were subsequently built, while the facilities at hand permitted their being manufactured in quantity.

Though both dirigibles and airplanes were still being built for war purposes, others were constructed for commercial uses, for pleasure, and for scientific purposes. A review of some of the more important accomplishments of air craft during the past ten years will help us to understand what has been and is now being done in aviation.

In May, 1919, three United States Navy seaplanes flew from Newfoundland for Europe. Only one of them, the NC-4, finished the journey which ended at Lisbon, Portugal. This was the first crossing of the Atlantic by airplane, but it was not a flight from continent to continent, because a stop had been made at the Azores. During June of the same year, Captain Alcock and Lieutenant Brown, of England, flew from Newfoundland to Ireland in 16 hours and 20 minutes. Four years later Lieutenants Kelly and Macready of the United

States Army crossed the United States from coast to coast in a non-stop flight, a distance of 2700 miles in 26 hours and 50 minutes. The time for this trip was reduced, in 1924, to 17 hours and 52 minutes by Lieutenant Maughan in his

Courtesy The Curtiss Corporation

A CURTISS BOMBER

dawn-to-dusk flight. Then, in 1924, six United States Army flyers encircled the globe in 351 hours of flying time.

But far more striking than any of the preceding feats was Commander Byrd's flight of May 9, 1926. He, with Floyd Bennett, was the first man to reach the North Pole by air. The machine which he used was a Fokker monoplane equipped with three 200 horse power Wright engines. It was 42 feet 9 inches long with a wing expanse of 63 feet 3 inches.

It was capable of a speed of 117 miles per hour. Starting from Spitzbergen, he made the journey of 1500 miles to the Pole and back in 15 hours and 51 minutes.

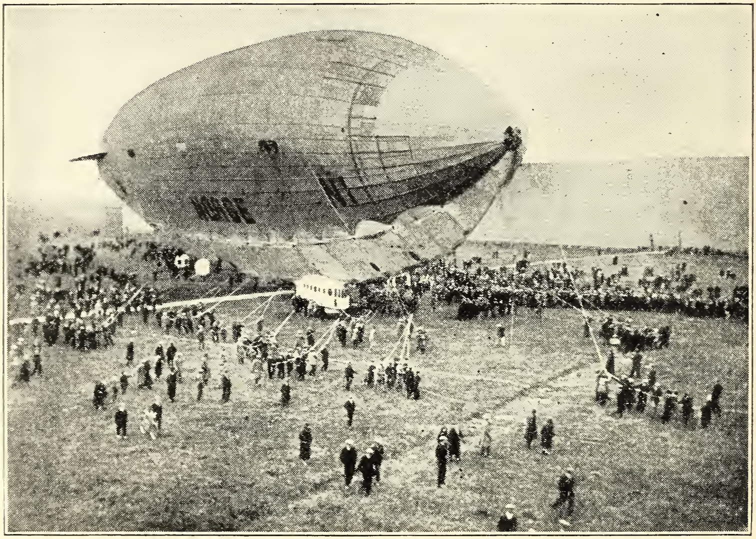
Since ordinary compasses are useless for determining direction when near the magnetic pole of the earth, other instruments had to be substituted for them. The Bumstead sun compass, an instrument working on a principle opposite to that of the sun dial, was employed. Knowing the time of day and keeping the hand of a 24-hour clock in line with the shadow made by the sun, Byrd was able to tell in which direction lay the Pole. The distance from the Pole was found by using the bubble sextant, an instrument employed for finding latitude. Another instrument which Byrd found to be of the greatest value was a drift indicator which told him how far the wind was carrying him from his course.

After reaching the Pole, he cruised around it in several circles and thereby gained a view of the Polar regions for many thousands of square miles. He saw nothing but vast fields of rough ice with here and there a smooth place where the ice field had separated and the water had frozen over again. These were interesting to him, as an aviator, since, had he been forced to land, he would have had a good landing field and one from which he could have taken flight.

Though the flight to the Pole in itself meant little more than the successful completion of a sporting event, it was a remarkable demonstration of what an airplane can do. It proved the reliability of the craft under unfavorable conditions and was therefore a triumph for science. That Byrd was able to travel 1500 miles in a region where ordinary navigating instruments could not be used and then return

to his starting point, indicates that travel by airplane has passed the elementary stage, and shows that intercontinental air lines over the Polar regions are feasible.

Two days after Byrd had reached the Pole, the Amundsen-Ellsworth-Nobile expedition consisting of 17 men left Spitzbergen in a semi-rigid balloon, the "Norge," for the same destination. This airship, of Italian manufacture, was 348



Photograph by Underwood and Underwood
THE "NORGE" AFTER LANDING AT PULHAM

feet long and 79 feet high and had a capacity of 650,000 cubic feet. She was equipped with three 250 horse power motors, two of which were situated near the middle and one near the rear end of the vessel. She was capable of a speed of about 70 miles an hour and was able to carry a load of eleven tons. A vessel of this type is better able to withstand

stormy weather than is the rigid balloon, because the upper part is flexible, the only rigid part being the keel.

During the first part of the trip from Spitzbergen to the Pole, no difficulties were experienced, but during the last seven hours dense fogs were encountered and ice froze on all parts of the craft. In spite of these hardships, however, at 1:30 A.M., May 12, 1926, the Pole was reached. After Norwegian, American, and Italian flags had been dropped, the ship continued toward Nome, Alaska. Soon impenetrable mists and storms were encountered. Ice collected on the vessel and interfered with the engines. Chunks of ice, falling upon the propeller, were hurled against the fabric of the balloon and caused some damage. There was constant danger of their tearing holes in the gas-containing bags and thereby causing the escape of the hydrogen. At length, worn out by the long fight, facing a continuation of the severe weather, and not knowing conditions ahead because their radio apparatus failed to work, they made a landing at Teller, Alaska. Three days and three nights had been consumed in making the flight of 3300 miles. This expedition proved, as that of Byrd's had done, that it is possible to navigate the Polar regions by air, and that, consequently, passage between the East and West may be made by this route.

Among the other outstanding flights of 1926, was that of Alan Cobham of England who flew from London to Capetown and back in a single-engined plane. His time was 94 flying hours from London to Capetown, a distance of 8020 miles. Another notable flight of 1926 was that of Commander Franco of Spain, who flew from Palos, Spain, to Buenos Aires, Argentina, in a seaplane, a distance of

6232 miles in 62 hours and 52 minutes. Still another was made by Captains Gonzalez-Gallarza and Loriga who flew from Madrid to Macao, Portuguese China.

A year after the epoch-making flights to the Pole, the most dramatic incident in the history of aviation occurred. Charles A. Lindbergh, in the "Spirit of St. Louis" (see Frontispiece, Third Book), rose from Roosevelt Field, Long Island, in the morning of May 20, 1927, and arrived at Le Bourget Field in the environs of Paris, France, on the evening of the next day. It is true that he was not the first man to cross the Atlantic Ocean in an air vessel, but he was the first to fly alone from continent to continent.

For his journey he chose a monoplane which he considered more efficient than a biplane, because of the absence of interference between wings, and because a monoplane can carry a relatively heavier load per square foot than other models. He decided upon a one-motor plane, because it offers less resistance to the wind and because it can fly a greater distance than a biplane, since it is able to carry a greater proportionate amount of gasoline.

His equipment included, among other things, maps of the regions over which he was to pass, a hydrostatic chart of the Atlantic Ocean, and an earth-induction compass. By following the maps and knowing the nature of the land over which he was passing, he was able to follow the route determined upon. But the compass was his main reliance while flying over the sea between Newfoundland and Ireland. This, when set in the direction of flight, indicates any deviation from that direction.

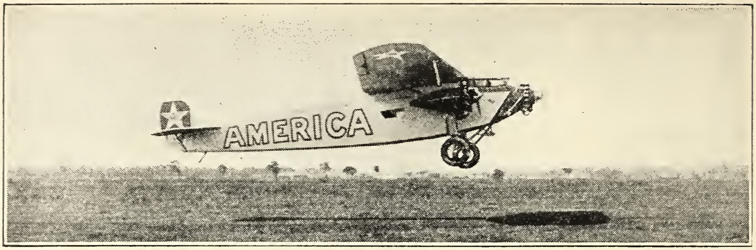
During part of the journey he was forced to fly "blind"

because of the presence of fogs. This means that he was dependent upon instruments to tell him his distance above the sea and his direction. Once, when flying through a cloud, ice began to form on his plane. This is one of the greatest dangers encountered in aërial navigation, because when ice collects on the edge of the wing it interferes with the control of the machine. Lindbergh, however, had no difficulty in flying out of the clouds into an area free from moisture.

Without mishap, the "Spirit of St. Louis" landed at Le Bourget Field 33 hours and 32 minutes after leaving Roosevelt Field, having covered a distance of 3600 miles. The achievement of Lindbergh again proved the reliability of the modern airplane engine and the dependability of the instruments used in aërial navigation. The subsequent triumphs of Lindbergh, who became an international figure over night, need not here be recounted because they are fresh in the minds of all. The impetus which he gave to aviation in this country will be touched upon later in this chapter.

The same year Commander Byrd with three companions flew to France for the purpose of furthering the development of aviation and strengthening the good will between France and America which Lindbergh had done so much to foster. The flight was originally conceived of by Rodman Wanamaker and was backed by him. Byrd took advantage of everything known to science which might make his journey safe and sure, since he wished to build up a body of knowledge which future navigators might use.

Like Lindbergh, he chose a monoplane, but, instead of having one engine, his plane was equipped with three. A



Courtesy Atlantic Aircraft Corporation

COMMANDER BYRD'S "AMERICA"

three-motor plane has a great advantage over one equipped with a single engine—if one motor stops running, there are two more to carry on. Byrd was not daunted by the accidents which had befallen his predecessors who had attempted to fly in machines of this type, namely, Davis and Wooster, in the "Pathfinder," and Fonck in his Sikorsky.

The United States Weather Bureau and the Radio Corporation of America coöperated in ascertaining the weather conditions prevailing over the North Atlantic. A weather map of that region, for the first time in history, was prepared. When advised by the Weather Bureau that the conditions prevailing between America and Europe were fairly satisfactory, he decided to start without waiting for ideal weather.

Thus the huge Fokker plane which bore the name "America," carrying its load of 15,000 pounds, started from Roosevelt Field on the morning of June 29th. Byrd, like Lindbergh, encountered dense fog which sometimes forced him to fly above the clouds. On several occasions he and his three companions were in imminent danger of being precipitated into the sea, for ice collected on the plane as it

passed through mist at high altitudes. But, again like Lindbergh, he was able to fly out of it in time. He also made use of the earth-induction compass.

While flying in the clouds, Byrd used the radio for ascertaining his position from passing ships, and, when approaching Paris in the dark, learned by the same means that the weather was foggy and squally. In fact, when near that city, he found that conditions were so bad that it would be unsafe to attempt a landing, so he was forced to return to the sea coast where he hoped to make a comparatively safe landing on the water.

He was unable to see through the night and mist so could not tell how far he was above the water. This he learned by dropping flares which blazed into flame when they came in contact with the waves. But when the plane descended it struck the water with such force that the landing wheels were torn off. As soon as the machine came to rest, however, Byrd and his companions, by inflating the rubber boat carried for such an emergency, were able to row to shore. Though Byrd was forced to make a landing on the sea, the very fact that he was able to land at all was a triumph for science. The earth-induction compass, the radio, the water flares, inflated boat, and various instruments in his equipment all contributed their share toward the completion of a difficult journey. The flight gave valuable information as to the cruising radius of a three-motored monoplane under unfavorable conditions and again indicated that transatlantic flying can be done with reasonable safety.

Among the other noteworthy flights of 1927 was that of Nungesser and Coli, who, starting from France for America,

disappeared never to be heard from again, the aërial journey of Chamberlin which ended in Germany; and the attempts of Ruth Elder and Mrs. Grayson to fly from New York to Paris.

Besides these and other flights involving long distances, aviators have made records of other kinds. They have flown at the rate of more than 300 miles per hour; they have remained in the air for more than 50 hours; and they have risen to a height of over six miles above the earth. Records like these, while not always of a practical value, nevertheless give an index of the capabilities of the machines which make them and indicate some of the strides which have been made in conquering the air.

This review of the spectacular flights made during the past few years shows that the world is active in the development of flying. The part played by the United States is impressive. It is true that in certain phases of commercial flying, as the carrying of passengers, some countries, like Germany, are far ahead of us. This is due to the granting of subsidies by these governments. Since the United States has not given such aid to aviation, private individuals have had to bear the cost of the operation of the airlines that have been established. Though this country lags behind some of the others in certain phases of aviation, it is in the front rank in others. Major Gardner, the editor of *Aviation,* reports that in 1925 commercial flights in the United States aggregated 6,823,730 miles, a figure larger than that of any other country. This total does not include the mileage made by 700 pilots whose records were not received at the time of compilation. Since flyers in this country are not required to report

their flights to any central bureau, the magnitude of their collective achievements is not generally known.

As early as 1919 an air mail route was established between New York and Chicago. In 1924 a New York to San Francisco route was begun. Among the air mail lines now in operation are those between Chicago and Dallas, New York and Boston, and Seattle and San Francisco.

In addition to the carrying of mail and express, the airplane is used to make aërial surveys and maps, to investigate conditions in flooded regions, to carry food, medicine, and physicians in emergencies. It is extremely useful for patrolling forests for the detection of forest fires. Regular air patrols are in operation in the United States and Canada. The airplane is also used for scattering gases and other poisons for destroying insects in infested regions. These and other activities show that the sphere of influence of the airplane is rapidly widening.

Much, however, needs to be done before the airplane will come into its own. One of the most crying needs of the present is the construction of landing fields. These are necessary in all cities and at frequent intervals along lines traversed by aviators. Money must be provided for the development of improved types of air craft and for the education of the public in aërial matters.

Certain far-seeing men, like the St. Louis citizens who financed Lindbergh's flight, the late Rodman Wanamaker, and Edsel Ford, have been responsible for some of the greatest achievements in aërial navigation. But the most valuable step has been made by Daniel Guggenheim.

In 1926 he established the "Daniel Guggenheim Fund for

the Promotion of Aëronautics." The work of this Fund, including the use of its $2,500,000, consists of two parts: the development of aircraft and the dissemination of aëronautical knowledge. The fund has offered a first prize of $100,000 and five second prizes of $10,000 each for the machine which will embody the best qualities of the present day machines and still be a safe means of travel. For the advancement of aëronautical education, schools of aëronautics have been established at New York University, Massachusetts Institute of Technology, California Institute of Technology, Leland Stanford University, and the University of Michigan.

A committee of school superintendents has been formed to provide for elementary education in the science. This Fund has given financial assistance to aëronautical societies in America, France, England, and Italy. It has formed a committee to further aëronautical meteorology. In addition, it has financed some of the tours for the spread of aëronautical knowledge made by Commander Byrd and Colonel Lindbergh.

After Colonel Lindbergh had completed his tour of the United States, on which he delivered addresses in the principal cities, Harry F. Guggenheim, the president of the foundation said, "Results are found in the fact that there was a very marked increase in air mail in each city visited by the plane, a great stimulus was given to the building of airports and there was also an increase in private flying, and in the number of planes sold to individuals."

Though much has been done toward the conquering of the air, aviation is still an infant industry. It needs governmental assistance, the coöperation of individuals, and the

education of the people at large in aërial matters. The "Spirit of St. Louis," the "America," the "Norge," and a host of other air ships have shown us what can be done. It remains for us to use the knowledge thus given us to do our part toward the further development of aviation.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What instruments did Byrd make use of on his flight to the Pole?
2. What is one of the greatest dangers that the aviator must face?
3. Why did Lindbergh choose a single-motored monoplane?
4. Why did Byrd make his transatlantic flight?
5. What difficulties did the "Norge" experience on its trips over the Pole?
6. What is now being done to further aviation?
7. What else needs to be done?
8. What are some of the things that the Guggenheim Foundation has already accomplished?
9. In what ways can the airplane and balloon be used?
10. What can our government do to aid in the development of aviation?

CHANGING MEANS OF COMMUNICATION

The War of 1812 between the United States and England was terminated in December, 1814, by the treaty of Ghent. Two weeks after its signature the Battle of New Orleans was fought, for it was not known in America that the treaty had been signed. It was not until February, 1815, that a ship arrived bringing tidings of the event. Today it takes but a few seconds to send a message across the sea. Thus have the means of communication changed! The same slow development which characterized transportation is thus seen to have been true of communication. The communication of information to distant points has, until recent times, been dependent for the most part upon the methods used in transportation. It was not until electricity entered the scene that a type of communication was possible which was not dependent upon transportation. But even now we still rely, to some extent, upon our transportation facilities for carrying information from place to place.

In the early days of human history runners were employed to carry tidings. It was a runner who brought the news to Athens that the Persians had been overthrown at Marathon. It was by means of runners that the Aztecs were informed of the approach of Cortez and his conquistadores. The runner is still employed in undeveloped countries, like parts of Africa and Asia.

After the horse, the camel, and other animals had been domesticated, the mounted courier in many regions did the work which the runner had done. The Egyptians used

mounted couriers many centuries ago. History is full of their exploits even down to recent years.

With the introduction of the stage and other vehicles drawn by animals, regular routes were established in various parts of the world. Mail service was inaugurated between many points. Relays of horses were used to haul these stages; that is, the horses were changed at various points along the route, which greatly increased the speed and efficiency of the service.

But even in the early stages of communication, men and animals were not depended upon entirely for the spread of information. Various methods of signaling were employed. It is known that the ancient peoples used signals of smoke and fire for this purpose. When it was necessary to inform a nation that an important event had occurred, like the approach of an enemy, fires were built upon high places. The smoke from them could be seen for many miles by day and the flames by night. By a system of relays it was possible to carry tidings hundreds of miles in a short time. Signals of this kind were used by the ancient Hebrews and the Persians. Smoke was sometimes confined under a blanket and liberated in clouds at definite intervals. It was thus possible to use a code consisting of differently spaced puffs of smoke.

Among the Romans it was the practice to use a polished shield as a reflector and thus send a beam of light to a distant point. This method could be used only when the sun was shining, and was useful for only short distances. Later, the firing of a series of cannons situated within hearing distance of each other was sometimes employed to tell of the occurrence of an important fact.

Rockets have been used by the Chinese for centuries as signals in time of war. It is interesting to note that this primitive method of conveying information was extensively used during the World War. Colored lights and flares, also used centuries ago by the Chinese, were made use of in that great conflict.

The lantern has also been extensively used for signaling purposes. You will remember that Paul Revere made use of one to inform his countrymen of the approach of the British in the Revolutionary War. The raising and lowering of a lantern in a bucket was for a long time the method used in the British Navy for signaling ships.

Signals of various kinds, many of them resembling in nature the primitive ones which we have just described, are still in use. The brakeman can still be seen signaling the locomotive engineer by swinging his lantern. The method of wig-wagging used in war and by the Boy Scouts are but adaptations of the ancient signals. The semaphore, which notifies the railroad engineer whether or not the track is clear, is the same method of giving intelligence adapted to modern conditions.

Let us return to the methods of communication which have to do with transportation. With the advent of the sailing vessel it was possible to communicate with distant points. Mail service was established between most countries of the world, but it was slow and not always reliable, because of difficulties and dangers which attended sailing the seas.

After the invention of the steam engine, the sail boat gradually gave way to the steamship as a carrier of mail. From then on a steady improvement in mail service, not only

in speed but in regularity, occurred all over the world. The improvement in communication due to the invention of the steam locomotive was even more noticeable on land than it was on the sea, for the mail service which was begun at that time rapidly developed into the efficient system which we know today.

But now, in addition to the mail train, we have the automobile and the airplane. Mail service by automobile is as efficient as mail service by mail train. By it many isolated localities are brought into close contact with the rest of the world. The airplane represents the last word in the transportation of mail. Aërial mail service now exists between the Atlantic and the Pacific coasts and between many of our important cities.

The rapid transmission of information across the continents of the world has had much to do in modern industrial advancement. The spreading of knowledge through the newspaper and magazine has had a most remarkable educational effect upon the people of all countries. The rural mail delivery has broken down the barrier which formerly lay between the city and the country. Each individual now knows what is happening in his own country and throughout the world. The spreading of information is doing more than any other force to change the narrow ideas held by the people of most countries a century ago.

But another force, even more important than the steam engine, is at work spreading information over the globe. This is electricity. It is by the use of this force that much of our information is gathered and transmitted from one place to another. It works hand in hand with the newspaper and

the magazine, gathering for them the material which they pass on through their printed pages. It also makes possible the rapid communication between two persons though they be situated on opposite sides of the globe.

In 1835 S. F. B. Morse invented the electric telegraph. In a short time the important centers of our country were brought into close contact with each other by the telegraph wires which were strung between them. About the time of our Civil War, telegraph cables were laid across the Atlantic Ocean. Before long, cables were laid connecting the other continents with each other. Today the telegraph is a world-wide institution.

Alexander Graham Bell, in 1878, gave us the telephone. Until the beginning of the present century it was used almost entirely for long-distance traffic. But since 1900 it has entered almost every home. It is now considered one of the necessities of life. The telephone is of the most inestimable value to man, for it has removed many of the annoyances which formerly resulted from the difficulty of giving and receiving information without long delays. It has been a boon to man in his industrial, as well as in his personal relations.

And now we come to the transmission of information across space without the use of wires. As early as 1842 Morse was able to transmit signals across a space of sixteen feet without wires. But it was not until 1901 that Guglielmo Marconi made a practical application of what Morse had discovered. In that year he succeeded in communicating between Poldhu, on the coast of Cornwall, England, and St. Johns, Newfoundland. Rapid progress has been made in

wireless telegraphy since that date. A large fraction of the world's business is now carried on by wireless telegraphy.

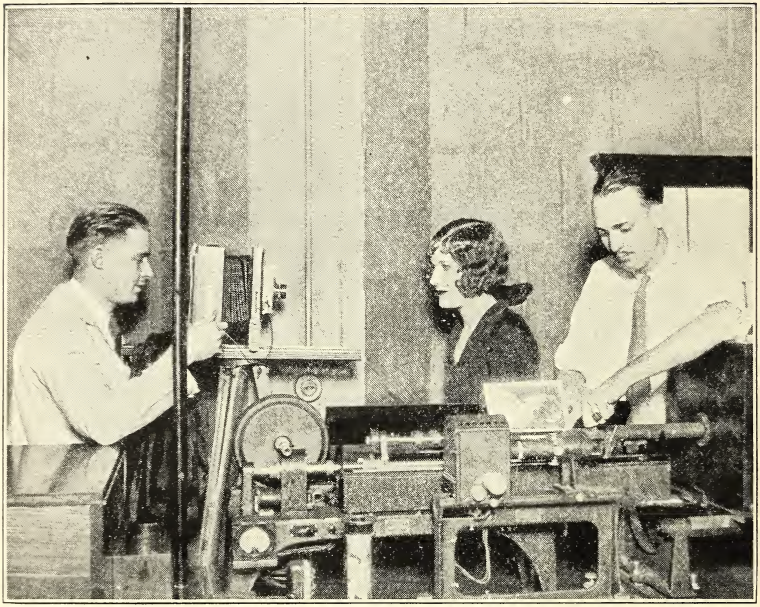
Wireless equipment on ships enables them to signal to other ships and to receive messages from them. On numberless occasions ships in distress have obtained aid from other ships and from the shore by the use of wireless messages. Many lighthouses are equipped with wireless outfits. They are thus able to be of the greatest assistance to ships at sea.

As the telephone followed the telegraph, so has the wireless telephone resulted as a development of the wireless telegraph. It may not be long before any man in America will be able to talk from his office to a man in Europe almost as easily as though they were both in the same town. Wireless telephony is already being used to some extent, but is too expensive to be widely employed.

Along with the evolution of the wireless telephone and telegraph has come that of the radio, with which we are all familiar. Sending stations in various parts of the country broadcast programs of all kinds. The receiving instrument in numberless homes change the waves which pass through the air into sound. The radio is the most efficient means of communication known, because by it all parts of the land can be informed of happenings at the same time. If a child is lost, or if some great catastrophe has occurred, no time is wasted in spreading the fact broadcast.

We are even able to send pictures by radio. People in all parts of the United States, if they have the proper instruments, can see the President as he delivers his message to Congress. Thus are not only sounds and signals but visual images transmitted instantaneously.

The accompanying illustration is of interest on this point. It represents a scene that took place in Los Angeles, California, and at once connected that city with New York. The photographer at the left took the young lady's picture and



Photograph by Underwood and Underwood

TELEPHOTOGRAPHY AT WORK

at once handed the printed photograph to the telephoto operator at the right. He placed it in his machine, and in half an hour a duplicate was delivered to the young lady's friends in New York.

Visual images of another kind—the motion pictures—give us information concerning happenings in the outside world. We can see far more clearly what has happened dur-

ing an earthquake than if we were to read printed words. We are given a clear understanding of the customs of people living in the far corners of the world. The moving picture, in conjunction with the phonograph, bids fair to be one of the most important agencies in the communicating of information on a large scale.

The transmission of information, begun in the early history of man when the first courier ran and culminating in our most modern electrical devices, is the most important civilizing force that has been at work upon mankind. It is bringing civilization to the savage and improving the condition of man throughout the whole world.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What were some of the primitive means of communication?
2. How did the Romans sometimes signal distant points?
3. In what ways are signals still employed for purposes of communication?
4. What have been the effects of modern means of communication upon the advancement of knowledge?
5. When and by whom was the electric telegraph invented?
6. By whom was the telephone invented? When did it come into general use?
7. For what important purposes is wireless telegraphy used?
8. What place in the dissemination of knowledge does radio hold?
9. How is the motion picture used for the dissemination of knowledge?
10. How does the steam engine aid in the spreading of intelligence? The gasoline engine?

CELLULOSE AND HOW WE USE IT

We have seen that the animal world is dependent upon the plant kingdom for existence, because the plants ultimately furnish the food supply of all animals. We have seen how the plants take the elements which are found in the air and the ground and recombine them into substances which will support animal life. But, in addition to this all-important function, the plants manufacture a material which is of inestimable value to man for numberless purposes. This material is called cellulose.

Cellulose is that substance which forms the walls of plant cells. It is cellulose that gives the young plant rigidity so that it can rise above the ground and withstand the winds that blow upon it, and it is cellulose that forms their bark and wood. If there were no cellulose, there would be no plants such as we know, for they would then consist of nothing but masses of jelly-like protoplasm. Cellulose, then, is the supporting structure, or backbone, of all the cells of a plant. Let us see in what way this substance is of use to us.

We saw in a preceding chapter that minerals cannot, as a rule, be used by man in their natural condition. The same is true of cellulose. The hand of the scientist, particularly that of the chemist, is necessary to transform this substance into a usable form. After he has done his work, the resulting products are such things as paper, cotton, celluloid, guncotton, and artificial silk. We have become so dependent upon most of them that they are classed as necessities.

Among the many uses to which cellulose is put, probably

the most important is that of the manufacture of paper. For countless centuries man drifted along in ignorance of what had happened in the past and of what was occurring around him. Knowledge gained in one generation was communicated only by word of mouth to the next. Ideas originating in one locality had little chance of being spread to other regions. It is true that inscriptions were sometimes made on stone, metal, and clay, but the process was extremely laborious and costly, and little information was disseminated in this way. But when man learned how to print and how to make paper, it was different. Printed matter could be scattered far and wide and be preserved for succeeding generations. The rapid strides in civilization which the world has made are linked up with the manufacture of paper. Since paper, which for the most part consists of cellulose, has had such important influence upon the advancement of mankind, it will be of interest to trace its manufacture from the beginning to the present day.

Many centuries before the Christian Era, the Egyptians made a crude kind of paper from a water plant called papyrus. It was from this plant that the word paper came. By beating strips of the stems of the papyrus plant and then soaking and pressing the pulp thus formed they produced sheets upon which men could write. Rolls of papyrus, as this early paper was called, which have been found in Egyptian tombs and other structures, still show the inscriptions made centuries ago.

Though the making of papyrus was understood 4500 years ago, it was not widely used until Alexander the Great introduced it to the rest of the civilized world. For many

centuries, papyrus was the only form of paper known to the races surrounding the Mediterranean Sea.

However, according to legend, paper had been made from waste silk in China for many centuries. At any rate, when the Arabs conquered a Chinese army in the eighth century they learned from some captured workmen the secrets of manufacturing paper from rags. The knowledge thus gained spread in time through Asia Minor and Northern Africa. During the twelfth century it was carried to Spain and Italy, and from thence to England and the rest of Europe. As early as 1690 a paper mill was built at Roxborough, Pennsylvania. In 1730, its manufacture was begun in Massachusetts. The paper of that and the preceding periods was made by hand. Since only one sheet could be made at a time the process was very slow and costly.

In France, in 1798, Louis Robert patented a machine which produced a continuous strip of paper. This was the first great step toward the production of this substance on a large scale. The machine, however, was not satisfactory. It remained for Henry Fourdrinier, in England, to perfect the machine which Robert had invented. The machine which Fourdrinier constructed was essentially the same kind of machine that is in use today. He is to be remembered, therefore, as the man who gave paper to the world in unlimited quantities.

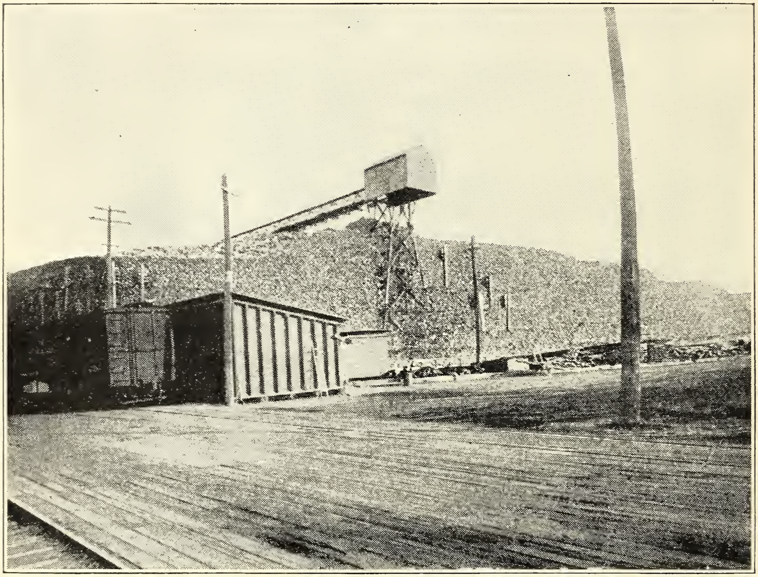
The use of paper now became widespread. Before long there were not enough rags to supply the demand. Paper manufacturers looked in every direction for satisfactory substitutes. Among the first plants which were used was the alpha grass, or esparto, which was obtained from Spain.

But it was not long before other sources were needed to meet the demand. Among the substances which were used were hemp, cotton, straw, bamboo, flax, and jute. But with the improved methods of transportation and of spreading knowledge which rapidly came into use, the demand for paper continued to increase. It was at this point that wood pulp was found to be a satisfactory material for making paper. It had the advantage over other sources of being of universal distribution and obtainable in large quantities. Today, although all the substances which have been named are used for making different kinds of paper, wood pulp is employed in far greater quantities than all the others combined.

Since hand-made rag paper was the first kind made, we shall consider the method of its manufacture first. The rags are first cleaned, then bleached in hot water containing chloride of lime. The next step is to cut them up into fine pieces and put them into a tank containing water. The mixture is then constantly stirred so that the rag fibers and water will be evenly mixed. Then a tray, the bottom of which consists of a screen of very fine mesh, is dipped into the mixture and immediately removed. After the water has drained off, a thin layer of pulp remains. The tray is now inverted, and the layer of pulp is deposited upon a felt cloth and allowed to become partially dry. It is next removed to the drying room where it is kept until perfectly dry. After being pressed or rolled, the sheets of paper are ready for the market. Our best grades of paper are still made by this process.

In the manufacture of paper from wood, two kinds of wood pulp are used—mechanical pulp and chemical pulp. Mechanical pulp yields coarse products like cheap cardboard,

coarse wrapping paper, and weather board, while the finer grades of paper are made from chemical pulp. The initial step in the preparation of both kinds of pulp is the same. Spruce, hemlock, poplar, and fir logs are cut into short



Photograph by Underwood and Underwood

PULP WOOD STORAGE, EDDY PULP MILL, HULL, QUEBEC

lengths, after which the knots and bark are removed. They are then ground by being pressed against a revolving grindstone. The resulting grindings are carried away by a stream of water, after which they are passed through a screen to remove the pieces which have not been ground into pulp.

Mechanical pulp contains, in addition to cellulose, all the other materials of which the logs consist, that is, lignin,

gum, rosin, and similar substances. It is the presence of these impurities that causes paper made from mechanical pulp to turn dark with age. Chemical pulp differs from mechanical pulp in that everything except cellulose is removed by the employment of suitable chemicals. It is a far more expensive process, but, as has been said, produces a much better grade of paper than does mechanical pulp.

Chemical pulp can be made by three different processes. These are the soda, the sulphate, and the sulphite processes. The oldest of these is the soda process, which was patented in England. This process requires the use of soft wood. After the bark has been removed, the wood is cut or ground into minute pieces and boiled in a solution of caustic soda under steam pressure. This removes everything but the cellulose. After being bleached and washed, a fine grade of white book and writing paper results. When the sulphite process is employed, the wood is put into a brick-lined tank which will hold about 30 cords. A solution of bisulphite of calcium is now pumped into the tank, the interior of which is under steam pressure. The paper which results from this process is strong and of good color. The sulphate process is similar—the main difference being that the chemical used is sulphate of soda. This process is usually used for the preparation of a rough tinted kind of paper, known as kraft stock, but it can also be used to make a soft white paper.

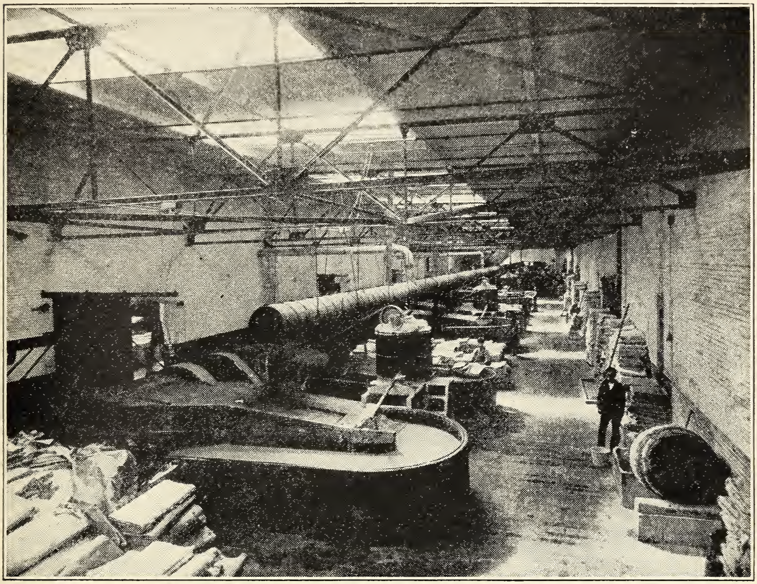
For the making of most newspaper and similar kinds of paper, mechanical wood pulp with 20 per cent sulphite wood pulp is used. To this, one part of china clay is added to act as a filler and to impart a finish to the paper. A solution of rosin soap in caustic soda is mixed with the pulp and clay

in the beating machine. Then an alum solution is added. In order to break up the materials into fine particles, what is known as the Jordan engine is frequently employed. This engine consists of revolving cones bearing knives that can be so regulated that they will cut the material into varying degrees of fineness.

The machine which is commonly used for making paper from mechanical pulp is called the Fourdrinier machine. The first part of this machine is an endless wire gauze belt about thirty feet long and as wide as the sheet of paper to be made. The wood pulp, flowing from a tank, spreads over this gauze, the thickness of the layer being regulated according to the thickness of the paper desired. The moving belt is given a vibratory movement which spreads the pulp evenly and causes the fibres of the pulp to unite into a compact sheet. If the paper is to be impressed with a particular design, a roller consisting of wire mesh revolves above it and presses upon its upper surface. "Water marks" are made in this way. From the wire-gauze roller the sheet of pulp passes on to a belt of felt, which carries it between steam-heated rollers. Most of the moisture having been removed, it leaves these rollers and, after being separated from the felt, continues through other rollers which exert great pressure upon it and give it a smooth surface. The paper, now finished, leaves the machine in the form of great rolls.

The various grades of paper differ with the materials used. The cheapest and coarsest products are manufactured from corn husks, various grasses, straw, and esparto. Manila hemp used to give us the kind of paper known as "manila." But now manila wrapping paper is made wholly of wood

pulp. There is, however, what is called "rope manila" paper which is made of old rope and other strong materials. Linen rags are the source of the high-grade "linen" which has the best finish and texture. Various substances like casein, clay,



Photograph by Underwood and Underwood
INTERIOR OF WOOD PULP MILL

and glue are applied to paper to give it a high glaze, and that used for illustrations is given a finish by passing it through a super-calendering machine.

In addition to that used for books, stationery, and newspapers, great quantities of paper are required for other purposes. It is used for making gas pipes, artificial bricks, and car wheels. Even boats, bottles, and houses are made of

paper. Papier-maché, which is made by pressing paper that has been soaked in water into a mold, furnishes us with many useful articles. Vases, boxes, articles of furniture, pails, and tubs are often made of this substance. The uses to which paper can be put are practically unlimited.

In the United States alone about six million tons of paper were made in 1925, about one-fourth of this being used for newspapers, besides three million tons for pasteboard, cardboard, etc. Almost a thousand paper mills are engaged in this industry.

Cellulose, which gives to wood fibres the properties that render them suitable for making paper and substances derived from paper, is utilized in many other ways.

Cotton, of which so much of our cloth is made, consists almost entirely of cellulose, as does flax, the plant which gives us linen. Likewise it is the cellulose in jute and ramie that makes them suitable for twine and rope.

In addition to substances in which the cellulose remains chemically unchanged, others are formed by the action of chemicals upon it which are very different from the original cellulose. Guncotton is one of these products. This is made by treating cotton with a cold solution of nitric and sulphuric acids, after which it is washed and dried. Guncotton is so explosive that it cannot be used in guns or cannons in its original condition because it would cause them to explode. In order that it may be used in them it is made into a paste by the addition of alcohol, ether, or acetone. It can then be molded into desired shapes and the rate of its explosion controlled. This mixture is called smokeless powder because of the small amount of soot that results from its explosion.

Guncotton combined with nitroglycerine produces cordite, a compound which explodes with terrific force.

But not all chemical combinations made from cellulose and nitric acid are explosive. When smaller amounts of nitric acid than that used in the making of guncotton are employed, a variety of products, called pyroxylines results. One of these pyroxylines combined with ether or alcohol gives us "collodion," popularly known as "new skin." Collodion, mixed with bronze or aluminum powder, yields a lacquer which is often employed for painting radiators and other metal articles. Artificial leather is made by applying a film of pyroxyline to canvas or other substances. Some of our shoes, and many bags, and automobile tops are made in this way. This cellulose product is also employed in the manufacture of films used in cameras and motion picture machines.

Another very important pyroxyline product is celluloid. This product is made by combining pyroxyline and camphor. Celluloid is extremely useful since it can be employed in so many different ways. When it is hot it can be molded, stamped, or blown; when it is cold it can be carved and turned in a lathe. It is familiar to all in the form of umbrella handles, combs, buttons, and innumerable other articles of everyday use. Celluloid has one great fault—it is extremely inflammable, as are most all pyroxyline products. Chemists have been unsuccessful in producing a non-inflammable celluloid that is not too brittle for most purposes.

Cellulose is the basis of our artificial silk. John Mercer, an Englishman, in 1844 soaked cotton yarn in caustic soda, which greatly increased its strength. But it was not until

1895, when Lowe, also of England, applied Mercer's process to cotton which had been stretched, that a satisfactory product resulted. The stretching of the flat cotton fibers which had been softened by the application of the soda caused them to assume a more rounded shape and thus to become more like the fibers of silk. Later it was found that cellulose could be dissolved and then forced through very minute holes. Since it hardened immediately upon passing through them, the result was long, round threads which bore a very close resemblance to the threads produced by the silkworm. It must be remembered that they consisted of cellulose instead of animal matter as do the strands of silk that are manufactured by the worm.

Scientists still continued to experiment with this process. Two modifications of Lowe's method, called the viscous and the acetate processes, have been found the most satisfactory. The making of artificial silk has reached the proportions of a gigantic industry. About fifty-two million pounds of this substance were manufactured in this country in 1925.

Another cellulose product is wood alcohol which will be of the greatest value to the world if our supply of petroleum gives out, since it can be used where gasoline is now employed as fuel for gasoline engines.

Though this material—the fundamental substance of all plants—has many uses, science is constantly finding new ways of utilizing it.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What is cellulose?
2. What influence has the making of paper had upon the advance of civilization?

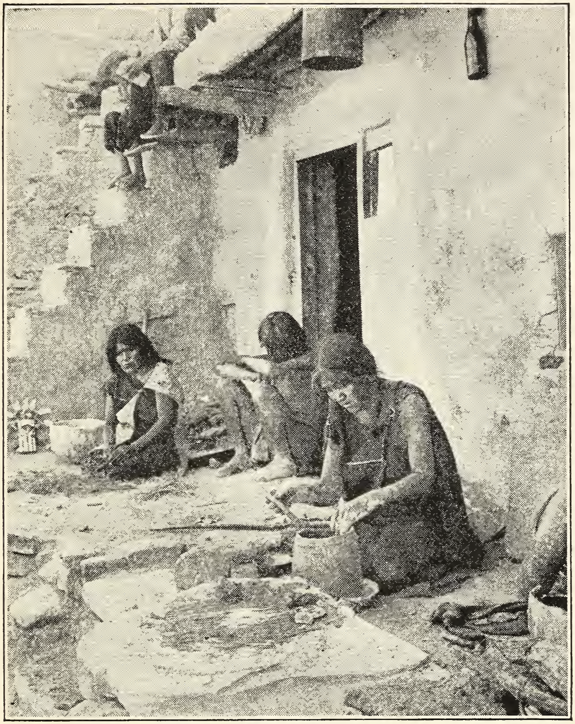
3. Give the early history of paper making.
4. What part did Louis Robert and Henry Fourdrinier play in the making of paper?
5. How is chemical pulp made? Mechanical pulp?
6. How is paper made from chemical pulp?
7. How is guncotton made? For what is it used?
8. Name some of the products made from pyroxyline.
9. For what purposes is celluloid used?
10. How is artificial silk made?

Bernard Palissy was born in a village near Bordeaux, France, about 1509. During his youth he learned the trades of glass painting and surveying. As a young man he traveled through France and Germany following now the one, now the other, as a means of livelihood. When about thirty years of age he saw an imported cup of unusual workmanship. Its beautifully glazed surface was far superior to the finish of the crude earthenware to which he was accustomed. His admiration of this article changed his whole career. From that day onward he devoted himself to learning the pottery industry with a view to discovering the secrets of pottery enamel.

For sixteen years he toiled, experimenting with all kinds of substances in abandoned furnaces. At last, after countless failures, he succeeded in producing a cup that was covered with white enamel. Encouraged by his success, he built a new furnace in which he baked vessels which had been coated with his chemical compound. Although he fired his furnace for six days without intermission, his preparation would not melt. Still undiscouraged, though his fuel and money were gone, he borrowed more and continued his experiments. Finally, one day, while his wife was proclaiming to the neighbors that her husband had gone mad, he succeeded in melting his preparation. When his oven cooled he found that his pots were covered with the desired glaze.

Palissy's products, however, were so crude that he could not market them. It took him eight more years to perfect

his enameling process. At length his labors were crowned with success and soon his fame as a potter of the first rank spread throughout Europe. Among the best known examples



Photograph by Underwood and Underwood
Primitive Pottery Making

of his skill are vessels decorated with artistic groupings of plants and animals in their natural colors. No modern potter has been able to surpass them in the beauty of their design or in the fineness of their texture.

Neither Palissy nor any other one man was the inventor

of pottery. The art of pottery making is as old as is the history of man. It did not originate in any one country, but came into being wherever and whenever man emerged from savagery.

A pot or a dish of clay was probably the first domestic article ever made by human hands. Clay and water, the only necessary ingredients, are present everywhere, and it would be surprising indeed if early man had not noticed that moist clay when dried in the sun retained its shape and became hard. It is probable that the first vessels were made by allowing lumps of clay that had been roughly molded by hand to dry in the sun. After the discovery of fire, man no doubt hurried the drying process by its aid. Such, we believe, were the beginnings of crude pottery making.

History tells us that the Egyptians and the people who dwelt in the Tigris-Euphrates Valley were making pottery of excellent quality 2000 years before Christ. But the Chinese, according to legend, understood its manufacture long before that. However, since no examples of Chinese pottery dating from a remote past have been found, China's claim cannot be allowed. It is also true that there is some evidence that pottery making was carried from the Tigris-Euphrates Valley to Egypt and China.

In the twelfth century the Moors conquered Spain and soon carried their knowledge of pottery making into Europe. In Spain they found lead and tin and were thus able to glaze their vessels with an enamel that contained these metals. Majolica, a kind of enamel ware, thus had its origin.

In Italy, Luca della Robbia and many other artists of the Renaissance period produced enameled ware of exquisite

texture and design. The art of making this ware was soon known in France. Rouen, Sèvres, and Saint Cloud became famous as centers of this industry.

It was not long before porcelain of many kinds was being made throughout Europe. On the continent, Dresden, Meissen, Berlin, and Copenhagen became renowned as pottery cities, while in England the industry flourished in Derby, Chelsea, and Worcester.

It was near the close of the seventeenth century that fine pottery was first made in America. Pottery works were then established at Burlington, New Jersey. Other American cities, famous as pottery centers, are Trenton, New Jersey, and Cincinnati and East Liverpool, Ohio.

There are four kinds of pottery: earthenware, stoneware, white earthenware (fine pottery), and porcelain (chinaware). Earthenware is made by baking coarse clay which has not been cleansed of its impurities. It is suitable for the making of such things as flower pots and drain tile, where fine texture and finish are not required. Earthenware was the first kind of pottery made by primitive man. Stoneware differs from earthenware in that a better grade of clay is needed, and this must be comparatively free from impurities. In addition, it is baked at a much higher temperature than is earthenware. Heavy vessels like crocks, sanitary equipment, and jugs are usually made of stoneware. White earthenware also requires a high grade of clean clay. The best grade of pottery is called porcelain, or chinaware. For its manufacture a special kind of clay called kaolin is essential. For many centuries kaolin was found only in China. For this reason porcelain is often called chinaware. In more modern times, however, large

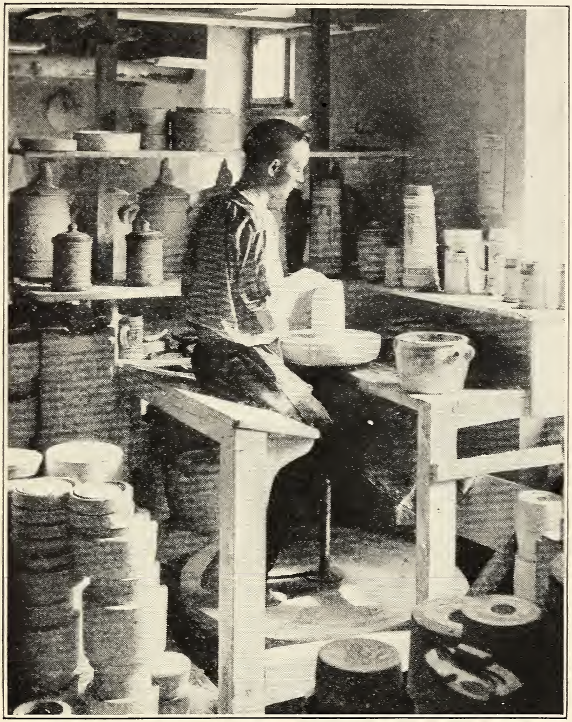
deposits of kaolin have been found in England, the United States, and other countries. Porcelain vessels are baked under intense heat which renders them exceedingly hard and gives them a smooth glass-like appearance. The finest examples of porcelain are pure white and translucent.

Though clay is the principal substance that enters into the manufacture of pottery, it is by no means the only material used. For earthenware and coarse stoneware, nothing else is needed, but for high grade pottery and for porcelain, various minerals, like flint and feldspar, are added to make it non-porous.

The first step in the manufacture of pottery of all kinds is the preparation of the clay. For earthenware and coarse grades of stoneware, the clay is merely moistened with water and kneaded until it is of a uniform consistency. For the better grades of stoneware and for porcelain the ingredients are thoroughly washed, after which the fluid mixture is forced through a filter to remove excess water. All lumps and hard particles are removed by fine sieves.

The next step is the molding of the plastic mass into the required shape. For centuries most of the pottery was molded on a potter's wheel which is a revolving disc on which the mass of clay is placed. As the disc turns around, the potter shapes the clay with his moist hands. The wheel is used for making vases, urns, bottles, and similar vessels. Some articles were molded by hand and others were shaped in molds. To-day machinery has almost entirely superseded all of these methods, although they are still employed in certain regions. Handles and other projections are molded separately and later cemented onto the vessel.

The article is now placed in a drying oven, after which it is removed to a kiln, or "biscuit oven," where it is baked, or fired. The best grades of porcelain are heated to a high



Photograph by Underwood and Underwood
POTTER IN SHOP

temperature which slowly rises for about thirty hours. Then, after the moisture has been driven off, the vessel is subjected to a very high temperature for several days. The result of this firing process is that the chemicals are melted and later become glass-like in consistency. As soon as this condition

is reached, the kiln is allowed to cool gradually. The article, now called biscuitware, is removed and dipped into a glaze of milk-like consistency, called a glaze slip. The article is again returned to the kiln and again fired. After hardening, this slip gives the vessel its glaze, or enamel. Stoneware is sometimes glazed by throwing salt into the fire. The fumes from the salt, forming a chemical union with the clay, produce a glaze.

Pottery, after it has left the "biscuit oven," is often given a pattern by applying to it paper that contains the desired design in pigments. After the pigments have been transferred to the vessel by low heat, it is put back into the kiln and baked again in order that the colored pattern may become fast. After cooling, it is dipped into a glazing mixture and again fired in the kiln. The result is that the pattern is protected by a thin film of enamel. Sometimes patterns and pictures are painted on the vessel after it has been glazed. This necessitates a third firing.

Today most of our pottery is made by machinery. However, the general procedure is the same as is here outlined. If we had to prepare the ingredients, mold them, apply the glaze, and perform all the other operations by hand, pottery would be almost as rare and costly as it was centuries ago.

In the development of every art and science, though countless individuals play their parts, there are always a few who stand out from the rest. In the pottery industry three men are preëminent: Bernard Palissy, Johann Bottger, and Josiah Wedgwood. You have been told about Palissy. Let us see what the other two contributed to the development of the art.

Bottger was born in Thuringia in 1682. Since he claimed to be able to make gold, the Elector of Saxony demanded of him that he do so. Upon his failure to produce the metal he was sent to work in the laboratory of the chief chemist at the Dresden Court. Instead of gold, he succeeded in making a red stoneware that resembled porcelain and later he perfected a process for making white porcelain. Since, in those days, white porcelain was about as valuable as gold, the Elector kept him a prisoner in his laboratory in order to keep his method of making white porcelain a secret. Before long, however, as a result of the treatment which he received, he died. The other workmen, fearing that they also would be held as prisoners, escaped and fled to various parts of Europe. In this way the knowledge of the making of white porcelain was spread broadcast.

The contribution of Wedgwood to the pottery industry was of a different nature. He was an Englishman, born in 1730. After learning the fundamentals of chemistry, he succeeded in producing stoneware and pottery of a kind that carried his name down to posterity. The most important accomplishment of Wedgwood was the making of high grade pottery on a large scale so that it could be possessed by all.

Due to the work of these men and of countless others who contributed their part to its development, the making of pottery is now one of the world's most important industries. The thousand and one different vessels that enter into our daily lives, the sanitary fixtures and equipment with which we are all so familiar, and many articles of beauty that brighten our homes all attest to the work of the men who have had a hand in the development of the art of pottery making.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What was the origin of pottery?
2. Name the four different kinds of pottery. How do they differ from one another?
3. What is the principal ingredient of pottery?
4. Where was kaolin first used for making pottery? Where is it now found?
5. By what process is porcelain made?
6. What is a potter's wheel? How is it used?
7. How are designs printed on porcelain?
8. What was Palissy's contribution to the art of pottery making?
9. For what are we indebted to Wedgwood?
10. Name six European cities famous for their pottery manufactures.

MAN-MADE LIGHT

The sun shone brightly in the eastern sky, for it was midmorning. Then gradually, although there was not a cloud in sight, its brilliance began to fade, while a strange light illumined the land. High in the trees and under the eaves of buildings the birds were seeking their perches as though they were preparing for the night. Groups of people were hurrying to open places, most of them carrying dark or smoked glasses through which they might observe what was happening in the heavens.

Slowly the light of the sun continued to fade, for the moon was passing between the earth and the sun. Finally there came an instant when the face of the sun was completely shut off from view. A total eclipse had occurred.

Suddenly, along the street, electric lights appeared, while in buildings the windows glowed as they do at night, for man, to compensate for the failure of the sun to do its work, was using lights which he himself had made.

The earliest men had no artificial lights. They depended upon the sun, moon, and stars for illumination. It is true that nature has other sources of light, for the firefly and the glowworm emit a dim radiance. It is possible that in the course of time the early men attempted to relieve the utter darkness of their caves at night by confining these small animals in vessels pierced with holes. This practice is followed by some of the inhabitants of islands of the Pacific Ocean today.

The first artificial light that man knew was the light from

his wood fire. Early in human history burning branches were used as torches. In this way light was carried from place to place. Some of these torches were knots of wood that contained rosin, or gum. They were very crude, and, in the course of time, were replaced by limbs of trees that had been soaked in oil obtained from animals and other sources. Oil-soaked torches found in caves of primitive man show that he had taken one of the first steps toward a higher civilization.

Primitive lamps were made by the Egyptians as far back as 4000 B. C. They consisted of small vessels, usually shells, for holding oil or fat and a wick made of some fibrous material. This type of lamp was an advance over the torch because, by regulating the size of the wick, the size of the flame could be controlled. Furthermore, the light from these lamps was fairly uniform while that from the torch was most uneven.

Following the Egyptian lamp, the Grecian lamp came into use, about 200 B. C. It was an advance over its predecessor because the oil was contained in a closed shell through which a wick passed. The oil, enclosed as it was within the shell, could not be ignited by the burning wick. The Grecian lamp, though an improvement over the Egyptian type, was still unsatisfactory, because the flame was not protected from currents of air. The shells of which these lamps were made were often carved with artistic designs. A kind of lamp, similar to the Grecian lamp, is still used by some northern peoples. Oil obtained from the whale, walrus, and seal is used as fuel.

The light used in colonial days of our own history was

obtained by burning tallow and wax in the form of candles. These candles were made by rolling tallow around wicks made of cotton or flax threads. They were then molded by hand into the shape desired. Beeswax was sometimes used in the making of candles. It could not readily be molded by hand so the melted wax was poured into molds.

Our colonial ancestors used candles not only in their houses but for lighting the entrances to them. In fact candles were used for lighting the streets. In order to use them out of doors it was necessary to enclose them in receptacles so that the flame might be protected from the wind.

The candlesticks into which the candles were inserted were made of brass, pewter, and other substances. Their bases were usually shaped in the form of a saucer to catch the drippings. Some candlesticks were very artistic and elaborate. Candelabra holding from one to five or more candles, from which glass prisms dangled, were widely used.

The next form of lighting was a lamp similar in general to the modern oil burner. It consisted of a closed receptacle containing a burner through which a wick passed. The principal fuel used was whale oil obtained from the sperm whale. Later, a glass chimney was placed around the burner. This resulted in a steady, uniform flame which was little affected by currents of air. Not only did these lamps give a steady and bright light, but they were fairly clean and could be moved from place to place without having the flame extinguished.

Oil lanterns, built on the same principle as the oil lamps were carried by pedestrians and were used on wagons. Lanterns of this kind are still widely used in rural communities.

In 1779, William Murdock, a Scot, used coal gas as a source of illumination. From then on the gas burner began to compete with the oil lamp. Before long, in most cities and towns, the gas flame, unprotected by a chimney of any kind, became the leading form of illumination used. The oil lamp, however, employing kerosene as fuel, continued to be used in many localities.

About 1800, shortly before gas came into general use, Sir Humphrey Davy discovered that a light could be produced between two pieces of carbon which were connected in an electric circuit. The arc lamp had entered the field. Since its introduction many improvements have been made in it. The modern flame arc lamp is the most efficient form of lighting known. It gives forth an intense brightness which makes it particularly well adapted for illuminating wide areas. For this reason, it is extensively used for street lighting. Sometimes these lamps, placed on high towers, shed their radiance over many city blocks. Some arc lamps generate heat amounting to about 7000 degrees F. For this reason they are not very well adapted to indoor lighting.

In 1878 Thomas A. Edison and J. W. Swan invented the incandescent lamp. It consisted at first of a thin filament of platinum within a glass bulb from which the air had been excluded. The next year Mr. Edison substituted a filament of carbon for the platinum thread. This lamp for many years was the type used for ordinary lighting purposes.

The incandescent lamp did not supplant the gas burner as rapidly as it was expected to, because, in 1885, Auer von Welsbach, an Austrian, invented the Welsbach mantle. This mantle gave the gas flame a uniform white brilliance which is

an excellent form of illumination. Another reason why gas is still widely used is the discovery of processes whereby it can be produced in the home. Kerosene and gasoline are the principal substances from which this lighting gas is produced.

Another kind of gas which is used for many purposes is acetylene gas. It is extremely brilliant and is therefore suitable for use in lighthouses, railroads, and similar places. It is very economical, and, for this reason, is becoming popular for lighting city streets and industrial plants.

In 1905, it was found that a metal filament, consisting of a rare mineral called tungsten could be used in place of the carbon filament formerly used in electric bulbs. This greatly lengthened the life of a bulb and gave it far greater brilliance. The tungsten bulb brought the incandescent lamp into general favor and its use is increasing rapidly. In 1913 it was discovered that if the bulb, after the air had been excluded, were filled with a gas like nitrogen or argon a still greater brilliancy would be obtained.

Another kind of incandescent light, constructed on a different principle, is being used to a limited extent. In this lamp, gas, instead of a filament of carbon or tungsten, is made luminous by the passing of a current of electricity through it. The entire content of the containing vessel is thus made luminous instead of just the filament which was the case with the carbon and tungsten bulbs. The high cost of manufacture and operation of these lamps, however, thus far prevents their being used on a wide scale.

Three different gases are used in these lamps. Neon which is used in one type is an extremely rare element. It is

obtained as a by-product in the manufacture of liquid air. The rarity of this gas prevents its being obtained at a reasonable cost. Carbon dioxide is the gas used in another type, but the great amount of electric current required makes it very costly. The third kind is mercury vapor. It is much cheaper than the other two, but it is not entirely satisfactory because it gives a ghastly color. There is another kind of mercury vapor, but this gives off ultra-violet rays, used only for highly technical purposes.

Lamps in which gas is made luminous are particularly well adapted to advertising and decorative purposes, because the tubes which are used can be made into any desired shape. A favorite form is that of handwriting.

The high-powered search lights with which steamships are equipped, the headlights of locomotives and electric cars, and the various brilliant lights used in industrial plants are all modifications of the forms of electric lights which have been mentioned.

Science has been able to isolate certain of the rays of which white light consists. The electric bulb which produces the ultra-violet ray is a lamp that does this kind of work. The light emitted by this bulb is used by the physician in treating various diseases, like cancer and skin infections.

The X-ray is another form of light which science has given us. By its use we are able to look through substances which before were opaque to the human eye. In the hands of the surgeon it is a most valuable instrument, for by it he is able to locate bullets and other foreign objects which sometimes enter the human body. The physician makes use of it in determining whether or not the organs of the body are

doing their work in a normal manner. He is also able to determine whether there are abnormal growths present within the body.

Before we leave the subject of artificial light, we must mention the way in which our houses and schools and offices

Photograph by Underwood and Underwood

BROADWAY AT NIGHT

should be illuminated. Only too often one is confronted by the bright glare of incandescent bulbs either located on the walls or suspended from the ceiling. Lights of this kind produce a severe strain upon the eyes. There is only one kind of artificial light that is entirely satisfactory. This is the kind called indirect lighting. The globes are located just

below the ceiling within a shade which throws the light against the ceiling. The rays of light are then reflected downward around the room. The result is that a uniform light of moderate intensity is diffused equally throughout the room. This is the kind of light which should be installed in every home, school, and office.

The various forms of artificial light have all played important parts in the advancement of human welfare. They have enabled us to travel in safety at night as well as by day. They have permitted us to utilize our time to good advantage, for our activities are no longer dependent upon the light of the sun. Artificial light has made the world far safer than it used to be because the criminal cannot carry on his trade with success under its glare. Artificial light enables us to use the microscope in our studies of the cause and nature of disease. It also is used for curing disease. Steam roads, electric roads, steamships, automobiles, and all other means of conveyance are dependent upon artificial light. It is evident that artificial light has played a most important part in the advances of civilization which the world has made.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What were the first sources of illumination known to man?
2. What were the earliest forms of artificial light?
3. Describe the Egyptian lamp; the Grecian lamp.
4. How were tallow candles made? Beeswax candles?
5. What contribution did William Murdock make to artificial lighting?
6. How is an arc lamp made?
7. Who invented the incandescent lamp? When?

8. For what purpose is the acetylene gas lamp particularly well adapted?
9. In what way are carbon dioxide, neon, and mercury gas used for producing artificial light?
10. For what purposes is the X-ray used?

HOW THE GOVERNMENT GUARDS OUR HEALTH

One of the most distinctive signs of the development of modern civilization is not the development of science, but the application of science to living. To be sure, the scientific work of Jenner, Pasteur, Lister, Trudeau, Reed, and others is noteworthy in itself. These men are to be respected for their contributions to pure science, but their greatest achievements have been in the application of their scientific studies to the problems of healthful living. In this we find their most significant contribution. It is in the application of the results of the researches of these men that lives have been saved and the world made a better place in which to live.

People generally do not know just what has taken place in the improvement of health conditions in this country. In 1885 the average length of life was thirty-five years. By 1925 it had grown to fifty-eight years, an increase of twenty-three years in four decades. Stated another way, for every year a person lived during the period from 1885 to 1925 a little more than one-half year was added to his life. This is a startling statement. The improvement of health during this period represents the most stirring achievement of the whole history of mankind. It is more significant, if less dramatic, than all the wars combined.

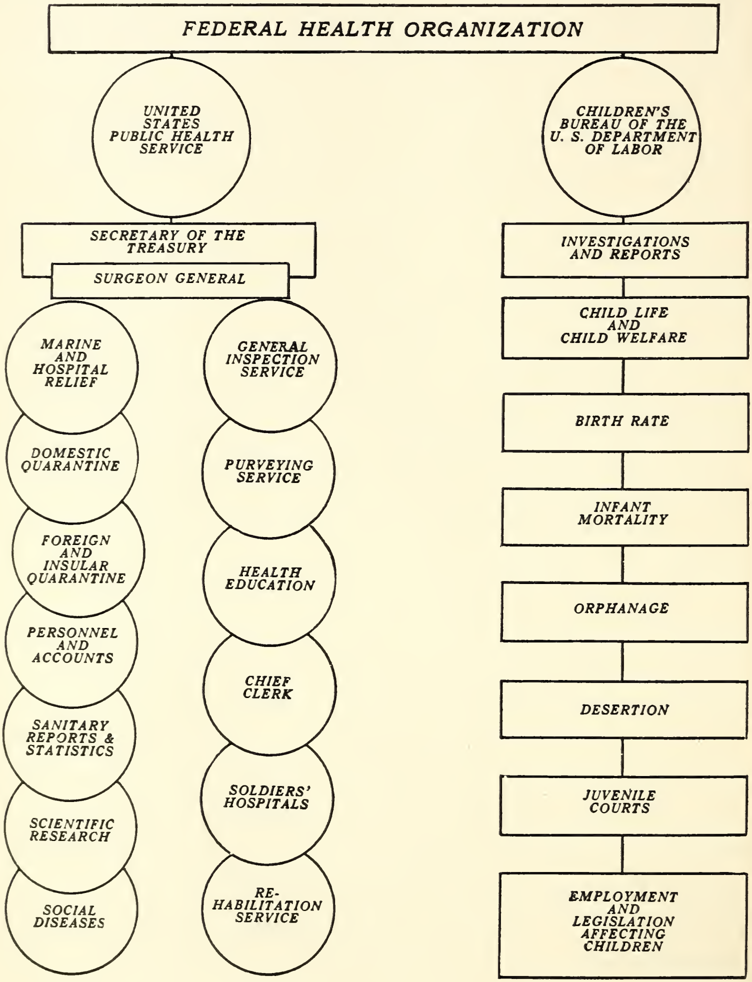
You will no doubt inquire in your own mind how this marked improvement in health and this amazing prolongation of life have been achieved. The simplest answer is that the celebrated men whose names are mentioned in this chapter have created a science of health which has made it possible.

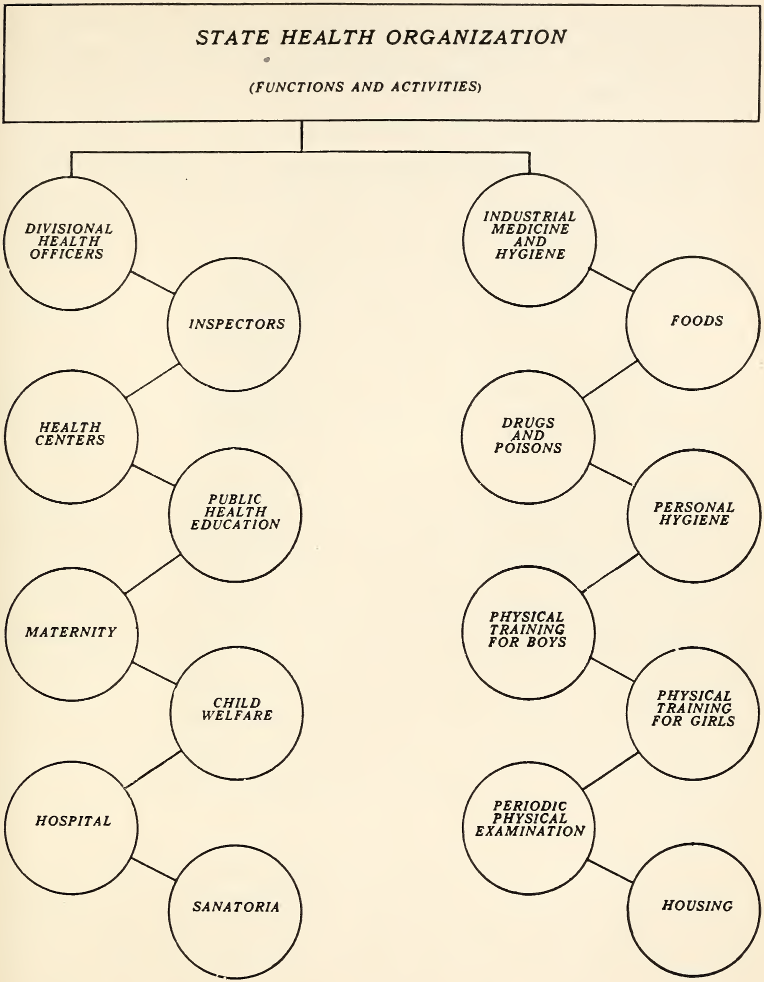
As one of the outcomes of that, we have learned how to control communicable diseases, and therefore how to prevent the plagues and scourges that in the past frequently visited communities. These are correct statements, but they do not fully explain what has taken place. Scientific discoveries themselves do not insure health.

We shall, therefore, have to look further than the achievements of the great heroes of science and health. We have already suggested that health improvement and the prolongation of life have resulted largely from the control of communicable diseases. The decreasing death rate among children is the result of the same cause. The maladies once so frequent have become comparatively rare. Smallpox has almost disappeared; cholera has practically vanished; tuberculosis and typhoid are almost under control; diphtheria and scarlet fever are fast disappearing. These diseases once took a heavy toll of human life. It is because of the decline of these and similar illnesses that life conditions have become better.

The decline of these notorious maladies has not been a matter of accident. It has been brought about by planned endeavor. We might say that the achievement could best be described in the terms in which the government—national, state, and city—guards our health. We have, perhaps, in the example of what our various governments have done in the improvement of health, the best example of the effectiveness of a democratic government. These achievements themselves justify our experiment in democracy. In spite of our muddling in politics and our evident failure in certain respects, we have here succeeded to a remarkable degree.

Perhaps the best way to show the elaborate character of the health work of our government is to present a diagram of the activities carried on. The diagram is self-explanatory.





There is no need to go into detail in this chapter in explaining the various activities in which the federal government engages in promoting our health. We have given

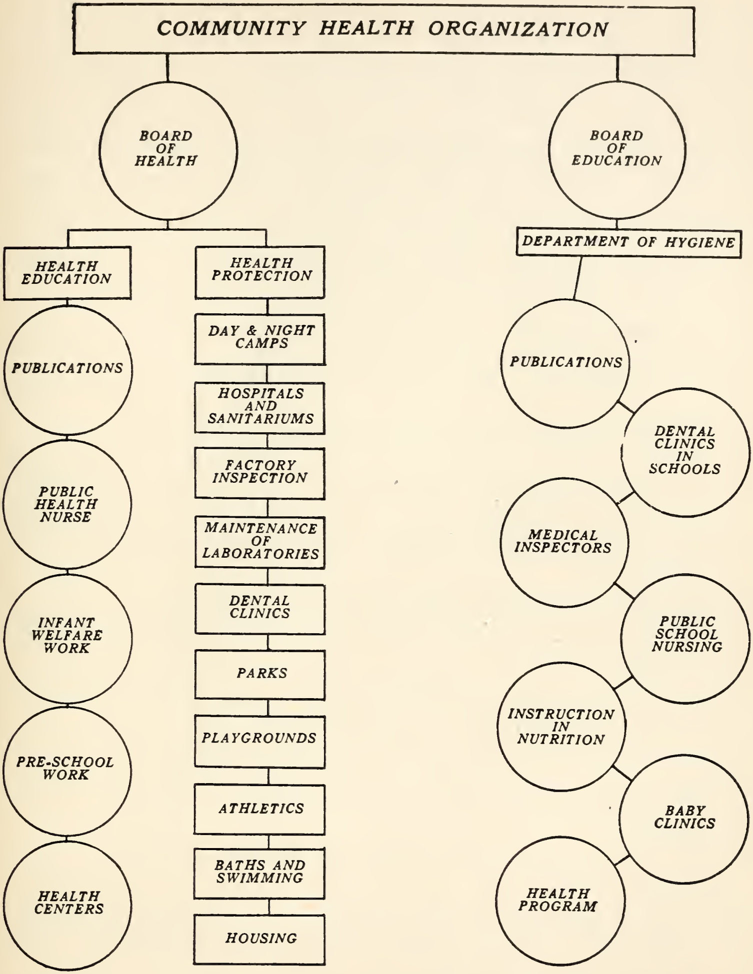
examples in the Third Book of this series in the elimination of yellow fever. The federal government guards the entrances to our country; it prevents the pollution of our interstate waterways; it guards our food supply, and prevents the general spread of communicable diseases. Uncle Sam stands guard, as far as possible, over the nation's health, and, while we sleep and work, we are protected by the vigilant and ever-wakeful eyes of the public health service.

No less active than the federal government are the state governments in the protection of our health. The chart on page 159 shows what our most advanced states are doing to apply the science of community living to the problems of health.

In this short chapter we cannot do more than intimate the extent of the activities of the state, and suggest that the reader compare the activities of his own state with those of other states to see whether his government is efficient from the health point of view. The Department of Health of New York State has started out to eliminate diphtheria from the entire state by 1930. This will undoubtedly be accomplished through the application of the Schick test. The state does for its people what the federal government attempts for the country as a whole.

The federal and state governments cannot, however, do all that must be done in the care of the health of the people of any community. Much of the work has been done in the past, and must be done in the future, by local boards of health. The chart on page 161 shows the extent of these activities.

A mere glance at the extent of the activities of the



national, state, and local agencies in the promotion of health gives the answer to the question: "How does the government guard our health?" A glance at these activities will also

indicate to us that science is not something merely to be learned in the school room. The great improvements in the community, whether they be in building, in transportation, government, or in health, are the result of the work of some man or group of men who are devoting their lives to the work of science. Oftentimes, they are sacrificing their lives without pay. Many times they are suffering for the necessities of life in order to make their contributions. Many of the men have been ridiculed and have suffered other hardships to make their scientific contributions without which improvements in living and health could not take place.

QUESTIONS AND TOPICS FOR DISCUSSION

1. In what way have scientists, like Pasteur and Lister, contributed to human welfare?
2. How has the average length of life in this country changed since 1885?
3. Name several diseases that are fast disappearing.
4. What are the principal activities of the United States Public Health Service?
5. In what ways does the Children's Bureau of the United States promote the health of our children?
6. How do the states assist in promoting the health of their citizens?
7. How do community health boards assist in improving the public health?
8. What are some of the health procedures followed in your school?
9. Could the decrease in the number of communicable diseases have been brought about without the aid of federal, state, and local organizations? Explain.
10. In your opinion which of these organizations has accomplished the most?

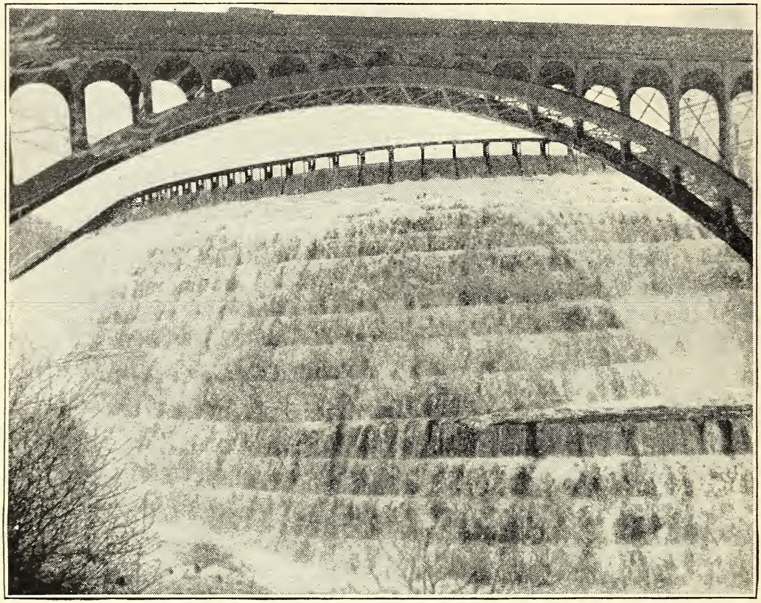
SCIENCE AND COMMUNITY PROTECTION OF OUR WATER SUPPLY

We have attempted to show graphically how the government uses the results of science in improving the conditions of living in the United States. Probably nowhere is this better shown than in the control of the water supply. The purification of the water supply provided for American cities is one of the results of the application of the science of chemistry. The extent to which scientific knowledge is used in the protection of health and welfare is a measure of the intelligent application of science in the community life. Community ignorance or community intelligence may be judged by the effectiveness with which science is applied to community living. No better example can be had than the water supply.

The three most vital necessities of human life are air, food, and water. Not only does one's comfort depend upon these factors, but an adequate supply of each is necessary for his continued existence. Man may live for days without food, a few days at most without water, and only a few minutes without air. The fact that a person cannot live long without these essentials is only one of the important facts connected with them. If they are not pure, they bring death just as surely if not as quickly. Therefore, the adequacy of water, air, and food depends as much upon their purity as upon their quantity. The pollution or contamination of any one of them is a serious disadvantage in the struggle for existence.

The growth and development of modern cities requires an enormous supply of water. New York City alone uses nearly

a billion gallons a day, on the average, and Chicago is not very far behind in amount. St. Louis, Cleveland, Detroit, and Boston each uses approximately one hundred million gallons a day. This enormous amount often necessitates that



Photograph by Underwood and Underwood
CROTON DAM AND RESERVOIR, NEW YORK

vast supplies of water be reclaimed from sources unfitted for use in their untreated condition. Chemistry makes possible the reclamation of this water for industrial purposes and for human consumption, and without this our large centers of population could not exist.

Water is a chemical compound formed by the combination of the elements of hydrogen and oxygen. The proportion

in the combination is two parts of hydrogen to one part of oxygen. We express this combination as H_2O. When you see this symbol you may know that it means water. The origin of water is the vapor of the atmosphere, or air, of the earth. The various forms of water with which we all are familiar are clouds, mists, dew, rain, snow, hail, and ice. In only one of these forms is water useful to satisfy directly the needs of the body. We can use snow and ice, but in that form they are not suitable for satisfying the needs of man.

Furthermore, water for domestic consumption and industrial uses, the principal purposes for which it is used, is derived mainly from rain, snow, surface waters, rivers, springs, and deep wells. As has already been suggested, the source of these supplies is the water vapor of the atmosphere. If the condensation of this vapor could take place without contamination, the water resulting would be suitable for the uses of man. But condensation does not so take place. Pollution begins with the very process of formation. The rain water itself may dissolve and hold gaseous, liquid, or even solid impurities. These impurities may be organic or inorganic matter which is present in the atmosphere. There are many such impurities in the atmosphere over cities and industrial works.

Water, may, therefore, be polluted by such impurities as carbonic acid, sulfurous acid, chlorine, ammonia, and the like that are in the air where the rain forms. This is the first source of pollution. Furthermore, water dissolves a greater variety of substances than any other liquid. Therefore, when it falls to the earth, it immediately begins to absorb organic and inorganic materials over which or through which it passes.

If we should analyze various waters, we should find them containing different minerals, depending upon the minerals in the ground through which they had passed. You have perhaps heard of Poland Springs, Saratoga Springs, Hot Springs, and many other places where mineral waters of various kinds are found. Among the mineral substances found in water are marble, potash salts, common salt, gypsum, sulphur, magnesia, lithia, etc.

Since the contamination of water begins as soon as it is formed from the atmospheric vapor and continues after it falls and courses its way along or through the earth, we cannot expect to obtain absolutely pure water from wells, streams, ponds, or lakes. We ought not to expect to drink water from any of these sources without knowing in advance that it is safe to do so, any more than we should from the ocean itself. The only untreated water that is usually safe to drink is that from deep wells, particularly artesian wells. It has been mainly through impure water that the scourges of cholera and typhoid fever have been communicated in the past. It is through the purification of the water supply that progressive communities have almost eliminated typhoid and have entirely eliminated cholera as communicable diseases. It is possible for every community to have an adequate supply of pure water. Whether a certain community does have such a supply depends upon the value it attaches to human life.

The facts so far presented indicate the necessity for treating water before it can be used with safety. The infections from typhoid in recent years have come from the use of unguarded water supplies, such as country wells and streams.

Water is treated for three purposes, each of which we wish to present: softening, clarification, and purification.

We have pointed out that water absorbs minerals. Perhaps you have used what is called "hard" water. You know the difficulty of getting your hands clean, besides the disagreeable taste that you experience, when the water is extremely "hard." Hard water is water that has absorbed certain minerals from the ground through which it has passed. Such water is not good even for industrial purposes. When hard water is boiled to make steam for an industrial plant, the minerals in it are deposited on the inside of the boiler, thus making a scale which insulates the boiler and the tube. This insulation causes a great loss of heat, thus requiring more fuel. In order, therefore, to use this "hard" water economically, it must first be softened.

The process of removing the salts causing "hardness" in the water is termed "water softening." The laundress and the housewife learned long ago to use wood ashes, lye soap, or other strong soap to wash the clothes when she was forced to use hard water. She was thus applying to her problem the chemical principle of water softening, although she may have been unacquainted with the principle as such. An English chemist, Dr. Thomas Clark, used lime as the first rational system of removing calcium and magnesium carbonates, and thus of softening water. Dr. J. H. Porter developed the soda ash treatment of water to reduce the permanent hardness. The Porter-Clark process, developed and perfected, is used today to soften billions of gallons of water annually. The softening process is now used, not only in the preparation of water for industrial purposes, but, in the central and far west-

ern portions of the United States, for household and city use as well.

The second purpose for which water is treated is that of clarification. People in the central Mississippi valley, when wells and springs no longer provided an adequate water supply, had to turn to the rivers to supply their needs. These rivers, however, carried a sediment of silt that made the water disagreeable to the taste, unsafe, and unsatisfactory for household use. The needs of the situation led to the modern clarification process.

While some of the simple methods of clarification of water date back to the early history of civilization, the efficient modern processes have developed quite recently. Alum and iron sulphate are widely used for this purpose. The alum treatment was developed about the same time as the Porter-Clark process of softening. The clarification of water in St. Louis was accomplished in time for the World's Fair held there in 1904, and somewhat later in most of the cities in the Mississippi valley. The steps already discussed, softening and clarifying, were marked advances in the treatment of water, because they made it usable for industrial and for some domestic purposes. They did not, however, purify the water and thus safeguard the health of the people using it. The next process to be described, therefore, is that of purification.

Most careful attention to purification has become essential for several reasons. In the first place, recall what has already been said in this chapter as to the prevalence of impurities in water and the sources of such. Then note the rapid growth of cities, requiring enormous quantities of water for

industrial and domestic purposes. The growth of plant life and other means of infection have also made it necessary, in the interests of health, to purify water designed for personal and domestic uses.

In addition to these sources of possible pollution, there is another, even more dangerous—sewage from cities. As cities increased in number and in population, sewage disposal became a very serious matter. This was usually accomplished by dumping the sewage into the very rivers or lakes from which the cities secured their water supplies.

"Necessity is the mother of invention." This is an old saying and as true in the case of water purification as in many other things. The demand for pure water led to epoch-making advances in the use of chemicals for that purpose. The modern chlorine treatment now assures a fairly certain non-disease-producing water supply for those cities and towns in Europe and America where it is used. The chlorine treatment of water provided for the soldiers of the World War did much to protect them from typhoid, a dreaded scourge of nearly all previous wars. As a matter of fact, typhoid fever has heretofore almost always run a race with the battles themselves in the destruction of life. The sole purpose in using the chlorine treatment is to destroy those organisms which produce disease, principally typhoid bacteria.

Probably no agency ever used in the improvement of public health has been more decided or effective than the use of chlorine in the treatment of water for the prevention of disease. In many instances the reduction of the death rate from typhoid was more than 70 per cent after using chlorine for the treatment of the water supply, and scientific opinion

gives credit to this chemical for the reduction. It has also been noted that the general health of the community, in addition to the specific reduction of sickness and death from special causes, has been improved by the purification of the water supply.

The specific reduction in the death rate from typhoid in New York City was 79 per cent; in Chicago, 88 per cent; in Philadelphia, 89 per cent; in Omaha, 88 per cent; and in Richmond, 77 per cent. This means the saving of thousands of lives as well as millions of dollars. Thus, chemistry, in providing a means for the purification of water, has rendered a service of inestimable value to industry and to humanity.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What is the source of our drinking water?
2. When may water become polluted?
3. By what substances may water be polluted?
4. Name some of the minerals often found in water.
5. For what three reasons is water treated by chemists?
6. How did Dr. Thomas Clark soften water?
7. In what way may water be clarified?
8. How effective is chlorine as a purifying agent?
9. What has been the rate of reduction in the death rate of several of our cities as a result of the purification of their water?
10. How does your community safeguard its water supply?

THE MEDICINE MAN AND THE DOCTOR

Perhaps in no place in the development of civilization have there been more marked advances made than in the application of science to health and healthful living. This is shown in the treatment of the sick, in medical practice, in preventive medicine, and in health practice. Scientific development has made these changes possible.

The contrast between unscientific and scientific living may be made clear by indicating some of the changes that have taken place since primitive times. Primitive man believed that disease was a manifestation of an evil spirit. Therefore, the method of preventing disease was to appease the evil spirits, and the method of curing the sick was to drive them out of the person afflicted. Medical practice consisted in ceremonies, incantations, dances, and other devices designed to overcome the evil spirits which possessed the sick person.

Such beliefs extended down into our civilization, far beyond the time of primitive man. You are familiar with the story of witchcraft, and with the burning of the witches of Salem. In our colonial days, even educated judges, lawyers, ministers, and business men believed that evil spirits came into the possession of men and women. As you know, men and women, suspected of being witches, were jailed, hanged, and burned at the stake. And these were regarded as civilized practices.

We have already learned that early medical practice, even in the nineteenth century, consisted mainly of bleeding and sweating, practices that we now know injured rather than

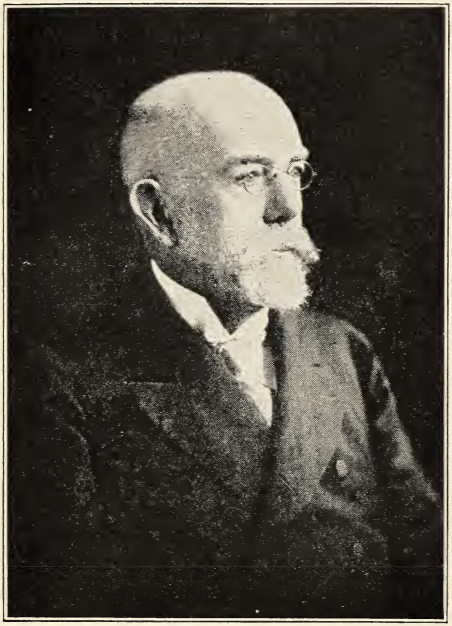
improved the sick. People who were sick with fever and needed all their blood to throw off the disease, were deprived of it at the most needed time. Undoubtedly, many people died from such unscientific practices. But in those days the spirit of science did not characterize medical practice. Indeed, science was then in its early stages of development and did not characterize any aspect of life. We learned to live by the trial-and-error method. We learned our mistakes after we made them. The development of science has made it possible to behave in specific ways and anticipate the results. We can therefore live by science, which means living by a plan, and thus avoid the evil consequences of wrong behavior. This has been made possible through science.

In order to appreciate what scientific progress and our present practices mean, we should note some of the beliefs and practices of the nineteenth century. Many people, in even the latter part of that century, believed that fresh air was bad for them and that it would make them sick. They believed that they should sleep with closed windows to avoid sickness. Trudeau was told by the doctor that he must not open the window in the room of his brother, sick with tuberculosis, because the air would be harmful to him. We now know that the first demand in the treatment for tuberculosis is for fresh air and sunlight.

Many people in the nineteenth century believed that malaria came from bad air. They had observed that people who lived in swampy countries had malaria, and so they thought that the bad air from foul water caused the disease. We now know that malaria is caused by the bite of a mosquito. We no longer avoid the air, but we kill the mosquitoes.

Some people then believed that gold beads worn about the neck would cure sore throat. We now know that sore throat results from a germ infection and that the way to cure the malady is to kill the germ. We go to the doctor for treatment, instead of going to the jewelry store to buy some gold beads.

Many people once thought that if a person were to scratch himself with a rusty nail or to stick one into his foot, he could ward off the harmful effects, usually an attack of tetanus, by immediately driving the nail into a board. This seems to us so stupid that we can hardly think that those who practiced such things were intelligent. They were intelligent but unscientific. They accepted a common belief without facts. Now we know that tetanus, or lockjaw, is caused by a germ and that inoculation is the only means of prevention.



Courtesy National Tuberculosis Association
Dr. Robert Koch

At one time people commonly believed that they could prevent cramps in their feet by turning their shoes upside down when they took them off at night. We might call this

belief a superstition, because it had no basis in fact. Somebody originated the notion, and it was handed down from family to family and accepted without scientific proof. Science has demonstrated that cramps in the feet are caused by wearing ill-fitting shoes. Scientific practice requires that we select our shoes intelligently, and that if we have flat feet we correct them by proper exercises.

Did you ever have a sty on the eye? If you should have, your physician would know just what to do, since the cause of the trouble is now well known. But it has not always been that way. People used to think that the way to cure a sty on the eye was to take a piece of paper, rub it on the sty, go across the road three times and say each time: "Sty, sty, go off my eye, go on the first one that passes by." They believed that this practice would cure the sty in two or three days.

Such superstitions and foolish practices went to great lengths in the days before developed scientific knowledge became related to behavior. To us they seem almost silly, but not so to the people who had not learned the results of modern science in its application to healthful living. True, many people do not even yet observe scientific practices in some of these, and similar, matters. But many of the crudest practices have been discontinued and others will be as scientific knowledge becomes more widely extended.

We have told of the great men and their contributions to the development of science and its application to the prevention of disease. We have also shown how the government uses these scientific advances in the promotion of healthful living. Marvelous things have been done. We have controlled yellow fever, typhoid, malaria, cholera, diphtheria, and we

have enormously reduced tuberculosis, all of which were at one time terrible scourges, all through the application of science to the community life.

The progress has been along two lines in the development of healthful living. The first aspect of the development has been in the direction of good health practices. We have learned that health is more than freedom from disease. We have discovered that it depends upon what we do and how we live, and its evidence is physical vigor, joy of life, enthusiasm in our activities, and optimism in our outlook on life. It depends upon what we eat, how we eat, how we exercise, and whether we live in the sunshine and open air or shut ourselves up in buildings. Health depends, in a word, upon the way we adapt ourselves to the environment in which we live, the way we meet our problems and solve them.

Another aspect of the modern health development under the influence of science has been away from the medicine man of primitive society to the scientific medical practitioner of the modern day. Formerly, as has been shown, man hoped to ward off disease by some activity that would appease an angry spirit. He tried to maintain his health by action toward an outside influence, mystical in character, which wished to injure him. We now know that both disease and health result from definite causes which are largely under our control. Sickness results from the violation of the laws of correct living. Vigorous health means right living.

If our automobile fails to work properly, we take it to the garage for repair; if our lights go out in the house we send for the electrician; if the gas leaks from the pipes in our store we send for the gas man, and so on. We do this

Courtesy National Tuberculosis Association
MEDICAL STAFF OF JOHNS HOPKINS UNIVERSITY

because these men have specialized in these fields and know what to do. It should be the same when we become sick, either as a result of improper living on our own account or of the actions of others in the spread of disease. We should select the person who has specialized in these matters to advise us as to what to do. We should send for the doctor, because he is the only man who has specialized in diseases and

knows how to recognize them and to treat them. The doctor is the scientific specialist in disease and it is wise to consult him if we are not well.

But what do many people do? Even though they patronize the automobile expert, and the expert in electricity, in time of need, they often go to the drug store and buy some patent medicine for themselves, if not feeling well. They know how to treat their automobiles, but do not know how to treat their own bodies. It is never safe to take medicine except upon the advice of some person who has specialized in diseases, who is therefore able to recognize their signs, and to prescribe for their treatment.

Many automobile owners have formed the excellent habit of having their cars thoroughly overhauled at least once a year, in order to keep them in the best possible running order. Why should not each of us exercise equal care in the treatment of his body? For the body as a machine is infinitely more wonderful and more intricate and delicate in its marvelous mechanism than the best car made.

One of the best ways to prevent disease and to maintain health is through the annual medical examination by the family physician or some other expert. He can do for us just what the automobile expert does for the car—enable the machine to run more smoothly and prolong its life and usefulness many years. The old saying, "An ounce of prevention is worth a pound of cure," is particularly appropriate to our health. We can be healthy by correct living and by discovering early the signs of approaching disease. Science has provided a body of laws of living, and the intelligent person will use them.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What were some of primitive man's ideas concerning disease?
2. What were some erroneous ideas concerning the nature of disease held during colonial times?
3. What is the true meaning of health?
4. To what extent were bleeding and sweating practiced up to the latter part of the nineteenth century?
5. What is meant by trial-and-error learning?
6. What were the nineteenth century beliefs concerning fresh air and night air? Wherein were they wrong?
7. How did our ancestors treat an injury made by a rusty nail?
8. Why did our ancestors follow such foolish practices?
9. When should we consult the doctor? Why?
10. Name the principal things on which health depends.

MILK AND SCIENCE

Milk provides one of the important sources of our food supply, and therefore one of the problems of modern sanitation has been to secure a safe supply of milk for the people of the whole country. In the first place, everyone, for a part of his life, has no other food than milk for his entire diet. Therefore, it is obvious that milk in its natural state supplies all the food essential for the maintenance of life and health. In addition to the fact that everyone lives for a part of his life upon milk, it is regarded as essential for the growth of boys and girls, and as an excellent, if not essential, food for adults.

The importance of milk as a food has often been emphasized in recent years by writers upon health. Dr. McCollum of Johns Hopkins University says: "The people who have achieved, who have become large, strong, vigorous people, who have reduced their infant mortality, who have the best trades in the world, who have an appreciation of art, literature, and music, who are progressive in every activity of the human intellect, are the people who have used liberal amounts of milk and its products." Secretary Hoover says: "The fate of the white races is indissolubly linked with that of their cattle. They cannot survive without dairy products."

If milk, then, is so essential for health, for physical vigor, and for national achievement, it is important, not merely to have plenty of it, but also to have milk that is pure. We have already noticed that water absorbs both organic and inorganic matter more readily than does any other liquid. We

have also noticed that putrefactive bacteria are often found mingled with this organic and inorganic matter that can be absorbed by water. Since milk is composed very largely of water, it likewise absorbs, and almost equally with water, the bacteria that cause disease. It is not an easy matter, therefore, to safeguard milk from disease producing germs. The securing of a safe milk supply thus becomes a vital problem of modern sanitation.

Securing a safe milk supply includes many and varied problems. In the first place, the milk must come from cows that are free from disease. This requires careful scientific inspection of dairy cows. In the second place, the milk must be so taken from the cows and so marketed as to prevent infection. The fact that milk passes through so many hands, in being transferred from the cow to the consumer, makes this an exceedingly difficult problem.

What do we mean by cows free from disease? The disease to which cows are subject, and for which adequate inspection must be provided, is bovine tuberculosis. Some states now require that all cattle be examined for tuberculosis. After the herd is examined and found to be free from the tubercle bacillus, it becomes the responsibility of the dairy owner to keep the cattle healthy. This may require that diseased cows be killed. In some states, a sum of money is set aside by the state to compensate the owner for any cows that have to be killed on account of tuberculosis. In the states where the dairies are so safeguarded, as in New York State, we can be reasonably sure that tubercular infection will not arise from the milk supply.

The inspection of dairies to prevent tubercular infection

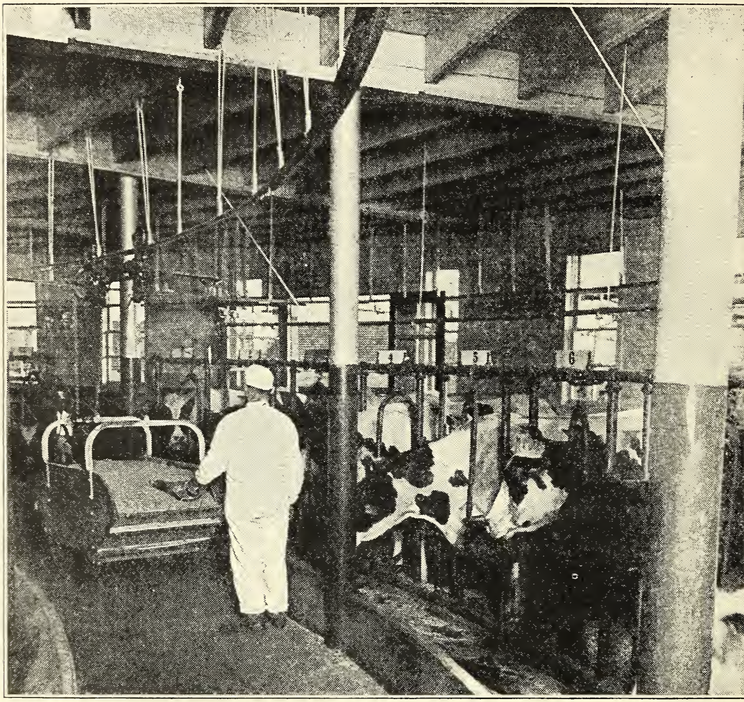
does not in any way safeguard the milk from other possible infections. As already suggested, there are many ways by which milk can be infected after it leaves the cow and before it reaches the dining table. To prevent infection, two methods of treatment are in common use: one gives us *certified*, the other, *pasteurized* milk. This matter is of such great importance that a brief description of these processes will be given.

The preparation of milk for certification is an expensive process. It demands, in the first place, cows free from disease, then cleanliness in the care of the dairy, chemical and bacteriological examination of the milk, and extreme care in its bottling. Certified milk is never sold from cans.

In some states, New York and New Jersey, for example, the laws are very strict in regard to these matters, and dairymen who wish to sell certified milk are required to conform to very definite practices. The plant in which the cattle are kept must conform to standard requirements. No one not connected with the care of the dairy may be permitted on the premises. A chemist and a bacteriologist must examine the milk and see that it is free from disease germs. The milk must be bottled and sealed, free from germs. It must then be sold within a period short enough to avoid deterioration.

This method of handling insures, not only that the milk will be free from all impurities, but that it will, as well, be in its natural state, thus containing all necessary food essentials, some of which are destroyed by the "treatment" called pasteurization. As has been said, certification of milk is an expensive process, but many people are willing to pay the higher price, especially when they wish the milk for young children, who need all the food essentials.

While certified milk provides the best food, especially for young children, it may not be absolutely pure, and therefore not as safe as pasteurized milk. In fact, the only sure



Photograph by Underwood and Underwood

A Clean Dairy

guarantee against harmful bacteria in milk is pasteurization. But this treatment destroys the vitamins and therefore removes some of the necessary food elements. For this reason, many people take the slight chance with certified milk for their children because it is the perfect food. When pasteur-

ized milk is used for children, they should also be given either tomato juice or orange juice for the necessary vitamins.

The question naturally arises as to what is meant by pasteurization of milk. The process is very simple and easily explained. It consists merely of subjecting the milk to a heat of 145 degrees Fahrenheit for a period of thirty minutes. In this time, all the bacteria are destroyed, and the milk is pure and therefore perfectly safe for all purposes. Nor does the heating harm the milk in any way except to reduce the vitamin content. After heating for pasteurization, the milk is either immediately bottled or at once cooled to fifty degrees or lower and later bottled. It is sold in the bottles.

All progressive cities of the United States require that milk sold to its people shall be either certified or pasteurized. Many cities no longer allow milk to be sold from cans. Many have ordinances against its being served in restaurants and hotels except in the original bottles.

A report from the Detroit Board of Health entitled: "Pasteurized milk is safe milk," indicates the importance of pasteurization. It says: "During the year 1926 a total of forty-one communicable disease outbreaks were reported to the United States Public Health Service as being due to milk. Thirty-one, or 75.6 per cent, were typhoid or paratyphoid fever outbreaks: six, or 14.3 per cent, were streptococcic sore throat: three, or 7.3 per cent, were scarlet fever: and one, or 2.4 per cent, was diphtheria."

There were, altogether, during that year, 1839 cases of disease, with 56 deaths, from infected milk. Of these, 1812 cases and 55 deaths, or 98.2 per cent of deaths, resulted from the use of "raw" milk, that is, milk that had not been

pasteurized. This means that only 27 cases of sickness and but one death resulted from the use of pasteurized milk. What more substantial argument is needed for saying that pasteurized milk is safe?

Detroit began to require pasteurization of its milk supply in 1915, and since that time has had no serious outbreak of disease due to infected milk. At the present time, more than 98 per cent of the milk supplied is pasteurized. This program on the part of the city government has no doubt saved the city from serious outbreaks of communicable diseases with all that they mean in deaths, in suffering, and in economic loss.

The inspectors of New Haven, Connecticut, report as follows: "If every farm and every cow could be frequently inspected and the methods of operation constantly under observation, it might be possible to produce raw milk that would be safe, but such constant supervision is an impossibility." This report, then, admits the impossibility of having pure milk that is not pasteurized. Certified milk, as indicated before, is fairly safe, but too expensive for the average family.

A report from the inspector of Hartford, Connecticut, indicates the problem of that city. The milk supply is within a distance which allows its distribution directly to the consumer by the producer. The inspector emphasizes the fact that raw milk can never reach the degree of safety from infection by contagious disease of human origin that is attained by pasteurized milk. The safest method for the production and sale of raw milk is for the producer to sell to his neighbors milk bottled on his premises under reasonable

supervision. We could easily cite hundreds of examples as proof that milk is safe only when it is pasteurized and sold in bottles.

The extent to which the community guarantees a safe milk supply represents one of the interesting modern developments in human welfare, and shows that a democratic government can adapt scientific methods to community living. Chemistry and bacteriology have provided us with a means of guaranteeing a safe milk supply even when it is marketed under modern conditions. We find various communities, although somewhat tardily, and with different degrees of effectiveness, making their practices, in the production and marketing of milk, conform to the exactions of science. This fact gives us great hope for the future of self-governing people in the control of their own lives in the interest of human welfare.

QUESTIONS AND TOPICS FOR DISCUSSION

1. What can you say concerning the need for milk in man's diet?
2. When may milk become contaminated by disease-producing organisms?
3. How does New York State guard against tuberculosis in cattle?
4. What is meant by certified milk?
5. What is meant by pasteurization of milk?
6. Which is the safer, certified or pasteurized milk? Why?
7. What has been Detroit's experience with milk?
8. What percentage of deaths in the United States in 1926 from infectious diseases resulted from the use of raw milk?
9. What desirable substance does pasteurization remove from milk?
10. What are the opinions of Hoover and McCollum concerning milk as a food?

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